DOCUMENT RESUME

ED 226 208 CE 035 108

TITLE	Optometry Specialist, 10-7. Military Curriculum Materials for Vocational and Technical Education.
INSTITUTION	Air Force Training Command, Sheppard AFB, Tex.; Ohio State Univ., Columbus. National Center for Research in Vocational Education.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
PUB DATE	78
NOTE	356p.
PUB TYPE	Guides - Classroom Use - Materials (For Learner) (051) -- Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC15 Plus Postage.
DESCRIPTORS	Allied Health Occupations; *Allied Health Occupations Education; Behavioral Objectives; Course Content; Course Descriptions; Curriculum Guides; High Schools; Learning Activities; Lesson Plans; Ophthalmology; *Optics; *Optometrists; *Optometry; Postsecondary Education; Secondary Education; Workbooks
IDENTIFIERS	Military Curriculum Project

ABSTRACT

These lesson plans and study guides for a secondary/postsecondary level course in optometry comprise one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in a civilian setting. The purpose stated for the 128-hour course is to train students in basic ocular anatomy and physiology, basic optics, use and maintenance of optometric testing equipment, visual therapy, medical ethics, medical technology and techniques, asepsis, and ocular first aid and emergency treatment. Introductory instructor materials include a course chart; a plan of instruction detailing units of instruction, criterion objectives, lesson duration, and support materials needed; and a specialty training standard for student performance evaluations. A lesson plan and a study guide are provided for each of two blocks of instruction: Introduction and Basic Optics (geometric optics, ophthalmic optics, professional and patient relationship) and The Visual System (anatomy and physiology of the visual system, the eye as an optical instrument, ocular emergencies and first aid). Lesson plans outline course content. The workbook includes objectives, informative materials, exercises, and answer keys. Several commercial texts, films, slide sets, and videotapes are recommended for use but are not provided. (YLB)

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL

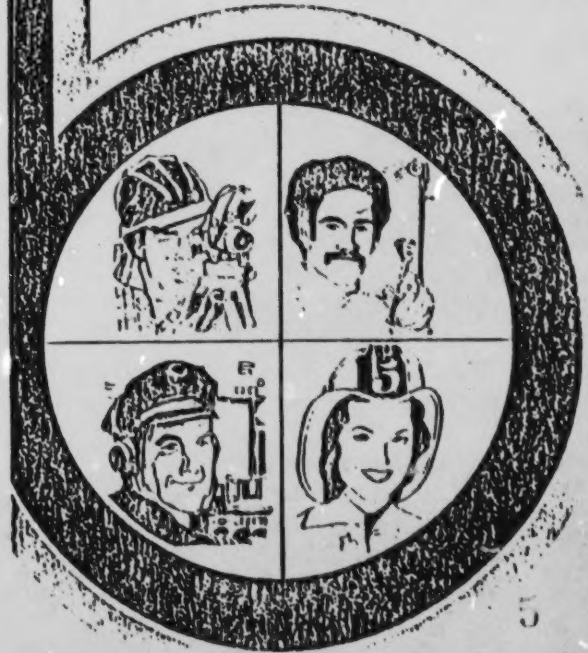
Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486 3655 or Toll Free 800/848 4815 within the continental U.S. (except Ohio)

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION

Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education



Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

OPTOMETRY SPECIALIST

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Lesson Plans Page 152

The Visual System - Study Guide and Workbook Page 179

Developed by:
United States Air Force

Development and Review Dates
June 25, 1975

D.O.T. No.:
079.108

Occupational Area:
Health

Target Audiences:
Grades 11-adult

Print Pages:
317

Cost:

Availability:
Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Contents:	Type of Materials:						Instructional Design:				Type of Instruction:	
	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Group Instruction:	Individualized:
			No. of pages									
Block I – *Introduction and Basic Optics*			107			★		★	●			
Geometrical Optics	●		●		★		●			★	●	
Ophthalmic Optics	●		●		★		●			★	●	
Professional and Patient Relationships	●		●		★		●			★	●	
Block II – *The Visual System*			146			★		★	●			
Anatomy and Physiology of the Visual System	●		●		★		●			★	●	
The Eye as an Optical Instrument	●		●		★		●			★	●	
Ocular Emergencies and First Aid	●		●		★		●			★	●	

★ Materials are recommended but not provided.

THE CENTER FOR VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY

Expires July 1, 1978

Course Description

This course trains students in the subjects of basic ocular anatomy and physiology, basic optics, use and maintenace of optometric testing equipment, visual therapy, medical ethics, medical technology and techniques, asepsis, ocular first aid and emergency treatment. The course contains five blocks of instruction but only two are suitable for vocational classroom use. The other three discuss specific military procedures, forms, and clinical practices.

Block I — - *Introduction and Basic Optics* contains three lessons covering 37 hours of instruction. Two lessons were deleted that introduced the military service and clinic procedures. Lesson topics and respective hours follow:

Geometrical Optics (18 hours)
Ophthalmic Optics (18 hours)
Professional and Patient Relationships (1 hour)

Block II — *The Visual System* contains three lessons covering 91 hours of instruction.

Anatomy and Physiology of the Visual System (58 hours)
The Eye as an Optical Instrument (29 hours)
Ocular Emergencies and First Aid (4 hours)

This course contains both teacher and student materials. The printed instructor materials include a course chart; lesson plans for each block of instruction; a plan of instruction detailing units of instruction, criterion objectives, duration of the lessons, and support materials needed; and a Specialty Training Standard for use in student performance evaluation. The student materials consist of a study guide/workbook for each block of instruction which contains information, exercises, and the answers to the exercises.

Several commercial texts are recommended for use with this course, but these are not provided. Audiovisual aids suggested for use by the instructor include 4 films and 18 slide sets and videotapes.

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COURSE CHART

NUMBER 3ABR91235	PDS CODE PDW	DATE 13 November 1975
COURSE TITLE Optometry Specialist		
ATC OPR AND APPROVAL DATE SGHE, 3 March 1975	CENTER OPR Sheppard/SHCS/MSOXC	SUPERSEDES COURSE CHART 3ABR91235, 25 June 1975
DEPARTMENT OPR Department of Biomedical Sciences		APPLICABLE TRAINING STANDARD STS 912X5, 3 March 1975
LOCATION OF TRAINING Sheppard AFB, Texas 76311		COURSE SECURITY CLASSIFICATION UNCLASSIFIED
INSTRUCTIONAL DESIGN Group/Lock Step		TARGET READING GRADE LEVEL FOR PREPARATION OF TRAINING LITERATURE 11.1

LENGTH OF TRAINING

(9 Weeks, 0 Days)

	Hours	
Technical Training		332
Classroom/Laboratory (C/L)	270	
Complementary Technical Training (CTT)	62	
Related Training		28
Standard Traffic Safety (AFR 50-24)	14	
Commander's Calls/Briefings	4	
End of Course Appointments; Predeparture Safety Briefing (ATCR 127-1)	10	
Total		360

REMARKS

Effective date: 18 November 1975 with class 751118

Applicable safety is integrated throughout the course.

TABLE I - MAJOR ITEMS OF EQUIPMENT

Vision Test Apparatus, Color Threshold
Lantern, Color Perception Testing
Projector, Ophthalmic Acuity Test
Tachistoscope, Visual Field Test
Perimeter, Ophthalmological
Table, Ophthalmic Instrument
Lens Measuring Instruments
Phoropter Unit
Lens Set, Trial, Ophthalmic
Light, Slit Ophthalmological
Keratometer
Retinoscope
Ophthalmoscopes
Fitting Set, CBR Mask Insert
Spectacle Fitting and Adjusting Set
Light, Color Perception Testing
Tonometer
Keystone Telebinoculars
Laser Optical Teaching Unit
Slide Projector or Cinemasound 1650
Autoplot
Strabismus Demonstrator

ATC FORM DEC 74 449 REPLACES PREVIOUS EDITIONS AND ATC FORM 449 B, NOV 72

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COURSE CHART – TABLE II – TRAINING CONTENT

3ABR91235

NOTE: Include time spent in technical training (TT) (classroom/laboratory (C/L) and complementary technical training (CTT)) and related training (RT). Exclude time spent on individual assistance (remedial instruction). A single entry of time shown for a unit is C/L time. When a double entry is shown, the second entry is CTT time.

WK OF TNG \ HRS PER DAY	1 2 3 4 5	6 7 8
1 2(2.2/5)	Course Material - UNCLASSIFIED 44 Hours TT BLOCK I - Introduction and Basic Optics Welcome and Orientation (4 hrs); The USAF Medical Service and Optometry Clinic (1 hr); Geometrical Optics (18 hrs); Ophthalmic Optics (18 hrs); Professional and Patient Relationships (1 hr); Measurement Test and Test Critique (2 hrs) 44 Hours C/L	14 Hours RT
2(2.8/5) 3 4 5(2.8/5)	Course Material - UNCLASSIFIED 122 Hours TT BLOCK II - The Visual System Anatomy and Physiology of the Visual System (58/20 hrs); The Eye as an Optical Instrument (29/7 hrs); Ocular Emergencies and First Aid (4/1 hrs); Measurement Test and Test Critique (3 hrs) 94 Hours C/L	24 Hours CTT 2 Hours RT 4 Hours CTT
5(2.2/5) 6(1.6/5)	Course Material - UNCLASSIFIED 31 Hours TT BLOCK III - Assisting the Optometrist Preliminary Ophthalmic Tests, Measurements, and Procedures (15/4 hrs); Additional Clinical Procedures (7/4 hrs); Measurement Test and Test Critique (1 hr) 23 Hours C/L	8 Hours CTT
6(3.4/5) 7 8(2.6/5)	Course Material - UNCLASSIFIED 88 Hours TT BLOCK IV - Spectacle Ordering and Dispensing Procedures Ordering and Dispensing Spectacles (63/22hrs); Measurement Test and Test Critique (3 hrs) 66 Hours C/L	22 Hours CTT
8(2.4/5) 9	Course Material - UNCLASSIFIED 47 Hours TT BLOCK V - Management and Practicum Publications and Medical Materiel Procedures (5/3 hrs); Environmental Safety and Accident Reporting (1 hr); Communications Security (Transmission Security)(1/1 hrs); Clinic Management and Practicum (34 hrs); Measurement Test and Test Critique (1 hr); Course Critique and Graduation (1 hr) 43 Hours C/L	4 Hours CTT 12 Hours RT

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10-7 5

DEPARTMENT OF THE AIR FORCE
Headquarters, US Air Force
Washington DC 20330

STS 912X5
(For AFSCs 91235/55/75)
3 March 1975

OPTOMETRY SPECIALIST AND OPTOMETRY TECHNICIAN

1. Purpose of this Specialty Training Standard (STS). As prescribed in AFR 8-13, this STS:

a. States in column 1 of attachment 1 the tasks, knowledges, and study reference (SR) necessary for airmen to perform duties in the Optometry ladder of the Airman Medical Career Field. These are based on Specialty Descriptions effective 1 December 1972 in Change 11, AFM 39-1.

b. Indicates in columns 2A, 3A and 4A of attachment 1 the minimum proficiency recommended for each task or knowledge for qualification at the 3, 5, and 7-skill level AFSCs. AFM 50-23 is the authority to change the proficiency level during JPG development when the local requirement is different from the skill level shown in this STS.

c. Shows in column 2A of attachment 1 the proficiency attained in Course 3ABR91235 (PDS Code PDW) described in AFM 50-5. Proficiency code for the minimum proficiency recommended for the 3-skill level AFSC and the proficiency attained in the course is the same, except when dual codes are entered. When dual codes are entered the second code shows the proficiency attained in the course.

d. Provides basis for supervisors to plan and conduct individual OJT programs.

e. Provides a convenient record of on-the-job training completed when inserted in AF Form 623, "On-the-Job Training Record," and maintained in accordance with AFM 50-23.

f. Defines the knowledge requirements covered by the Specialty Knowledge Tests in the Weighted Airman Promotion System.

2. Proficiency Code Key. Attachment 1 contains the Proficiency Code Key used to show proficiency level.

3. Career Development Channel of OJT. Satisfactory completion of CDC 91255 is mandatory for personnel training to AFSC 91255. Personnel training to AFSC 91275 will obtain knowledge training by using applicable study references listed in this STS, and fulfill management training requirements specified in AFM 50-23. (See ECI Catalog and Guide, Chapter 3, paragraph 3-5, for current CDC identification number for ordering purposes.)

4. Study Guidance for Weighted Airman Promotion System (WAPS). Specialty Knowledge Tests (SKTs) for promotion to E-5 are based on 5 skill level knowledge requirements. SKTs for promotion to E-6 and E-7 are based on 7 skill level knowledge requirements. SKT questions are based primarily on Career Development Courses (CDCs). However, some questions may be drawn from other references listed in this Specialty Training Standard. The CDCs for SKT study are maintained in the WAPS Study Reference Library. Other references listed should be available in the work area. Individual responsibilities are outlined in AFM 35-8, chapter 19, paragraph 19-3g.

5. Recommendations. Report to ATC/SG unsatisfactory performance of individual graduates or inadequacies of this STS. Refer to specific paragraphs of this STS. See AFR 50-38.

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

DAVID C. JONES, General, USAF
Chief of Staff

JACK R. BENSON, Colonel, USAF
Director of Administration

1 Attachment
Qualitative Requirements

Supersedes STS 912X5, 4 October 1971; Change 1, 12 February 1973; and Change 2, 24 April 1974.

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill Level		
	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
NOTE: Users may annotate lists of SRs to identify current references pending STS revision.									
1. CAREER LADDER PROGRESSION									
a. The airman career ladder and educational opportunities	B			C			C		
SR: AFMs 39-1, 213-1; AFVA 39-1									
b. Progression in career ladder 912X5	A			B			C		
SR: AFM 39-1 (atch 52, vol II): AFR 35-1; AFVA 39-1									
c. Duties of AFSCs 91235/55/75									
(1) AFSCs 91275, 91295	A			B			C		
SR: AFM 39-1 (atch 52, vol II)									
(2) AFSCs 91235, 91255	B			C			C		
d. Mission, organization, development, and function of the Medical Service and the Optometry Clinic	A			B			C	NO ADVANCED COURSE	
SR: AFR 20-28									
2. DISASTER PREPAREDNESS MEDICAL CARE AND FIRST AID PROCEDURES									
SR: AFMs 160-12 (chap 1), 160-34 (chap 5 and 9), 160-37									
a. Manage shock	2b/-			3c			3c		
b. Maintain effective respiration	2b/-			3c			3c		
c. Control hemorrhage	2b/-			3c			3c		
d. Perform emergency treatment of wounds	2b/-			3c			3c		
e. Manage fractures, burns, and injuries from chemical agents	2b/-			3c			3c		
f. Perform methods of hand and litter carries	2b/-			3c			3c		
g. Load and unload vehicles	2b/-			3c			3c		
h. Maintain military sanitation	a/-			1b			2b		
3. COMMUNICATIONS SECURITY (TRANSMISSION SECURITY)									
SR: AFRs 205-1, 205-7									
a. Identify information as classified, unclassified, or of possible intelligence value	b			b			b		

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill L.		
	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
3b. Identify official information as Top Secret, Secret, Confidential, or For Official Use Only	b			b			b		
c. Select and recommend mode of transmission dictated by security and expediency required	b			b			b		
d. Observe security precautions involved in communications	b			b			b		
4. ENVIRONMENTAL SAFETY									
SR: AFR 127-101 (chap 1, 5, and 14)									
a. Principles of general safety	B			C			C		
b. Exercise safety precautions during job performance	2b			3c			3c		
c. Accident reporting	A			B			C		
5. PROFESSIONAL AND PATIENT RELATIONSHIPS									
SR: AFM 160-34 (chap 1)									
a. Promote professional relations with patients and medical personnel	2b/b			3c			3c	NO ADVANCED COURSE	
b. Maintain professional standards of ethics	2b/b			3c			3c		
c. Perform duties with a high standard of conduct	2b/b			3c			3c		
6. PUBLICATIONS									
a. Use indexes to locate official publications	1a/a			3c			3c		
SR: AFRs 0 series, 5-4									
b. Locate required information in official and commercial publications	2b/-			3c			3c		
SR: AFMs 5-1 (chap 1, 2, 3, and 6), 168-4 (sec D, chap 1); AFRs 0 series, 5-4									
c. Initiate requests for official commercial publications	1a/a			2b			3c		
SR: AFM 168-4 (sec D, chap 1)									
d. Maintain publication files	1a/-			2b			3c		
SR: AFM 168-4 (sec D, chap 1); AFR 5-31									

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill L.		
	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
8. SUPERVISION AND TRAINING									
a. Supervision									
(1) Evaluate performance of subordinate personnel	-			2b			3c		
SR: AFMs 39-1 (atch 52, vol II), 39-62, AFR 39-6									
(2) Plan and schedule work assignments and priorities	-			2b			3c		
SR: AFM 50-20 (units 2 and 3); AFR 39-6									
(3) Prepare correspondence, reports and records	a			2b			3c		
SR: AFM 10-1									
(4) Establish work methods, controls, and performance standards	-			2b			3c		
SR: AFM 50-20 (units 2 and 3)									
(5) Recommend policy changes on utilization of personnel and equipment	-			2b			3c	NO ADVANCED COURSE	
SR: AFMs 26-1, 26-2									
(6) Resolve technical problems encountered by subordinates	-			2b			3c		
SR: AFR 39-6									
(7) Counsel personnel and resolve individual problems	-			-			3c		
SR: AFM 39-12; AFRs 35-32, 39-6, 39-30									
b. Training									
(1) Orient newly assigned personnel on standard operating procedures	-			2b			3c		
SR: AFMs 39-1, 50-20 (unit 4); 50-23, AFR 39-4									
(2) Recommend personnel for training	-			1b			3c		
SR: AFMs 39-1, 50-5, 50-23; AFRs 39-4, 50-[illegible]									
(3) Plan and conduct OJT programs, and refresher training	-			1b			3c		
SR: AFMs 39-1, 50-23, 50-6									

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill Level		
	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
7. MEDICAL MATERIEL PROCEDURES									
a. Air Force Accountability and Responsibility	B			C			C		
SR: AFR 67-10									
b. Prepare request for issue/turn-in of supplies and equipment	1a/a			2b			3c		
SR: AFMs 67-1 (chap 10, 11, and 18, vol 5), 167-240 (chap 10, 11, and 18)									
c. Report of survey system	A			B			C		
SR: AFM 177-111									
d. Supply procedures to include Classification and Identification	A			B			C		
e. Property accountability and responsibility	B			C			C	NO ADVANCE COURSE	
SR: AFMs 67-1 (chap 14, vol 5), 168-4 (sec C, chap 9); AFP 167-2 (chap 14, vol 5)									
f. Forecast, budget for and justify equipment and supply requirements	-			b			3c		
SR: AFMs 67-1 (chap 14, vol 5), 168-4 (sec D, E, F, chap 9); AFP 167-2 (chap 11)									
g. Use indexes and supply catalogs	a			2b			3c		
h. Initiate requests for standard and non-standard supplies and equipment	a			2b			3c		
SR: AFM 67-1 (chap 11, vol 5); AFP 167-2 (chap 5)									
i. Maintain equipment custodial account	-			2b			3c		
SR: AFM 67-1 (chap 14, vol 5)									
j. Maintain equipment replacement log	-			2b			3c		
SR: AFM 67-1 (chap 14, vol 5)									
k. Equipment specifications	A			B			C		
SR: Federal Supply Catalog, Identification List, C6515-IL-AF, "Medical and Surgical Instruments, Equipment and Supplies"; Federal Supply Catalog, Management Data List C6515-ML-AF, "Medical and Surgical Instruments, Equipment and Supplies". Federal Supply Catalog, Identification List C6540-IL-AF, "Opticians' Instruments, Equipment and Supplies". Federal Supply Catalog, Management Data List C6540-ML-AF, "Opticians' Instruments, Equipment and Supplies".									

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	2. 3 Skill Level A AFSC/Crs	3 Skill Level B Date OJT Started	3 Skill Level C Date Completed & Trainee's Supervisor's Initials	3. 5 Skill Level A AFSC	5 Skill Level B Date OJT Started	5 Skill Level C Date Completed & Trainee's Supervisor's Initials	4. 7 Skill Level A AFSC/Crs	7 Skill Level B Date OJT Started	7 Skill Level C Date Completed & Trainee's Supervisor's Initials
8b(4) Maintain OJT records	-			1b			3c		
SR: AFM 50-23									
9. GEOMETRICAL OPTICS									
a. Theories of propagation of light	A			B			B		
SR: Elements of Optics, (chap 1) American Optical Co., Vision in Military Aviation (chap 2); WADC TR 58-399									
b. The metric system of measurement	B			B			C		
SR: Fundamentals for the Optometric Assistant (chap 6); Bates, 1st ed., Chilton Press									
c. Wave length and color	A			B			C		
SR: Elements of Optics, American Optical Co. (chap 1)									
d. Reflection	A			B			B		
SR: Elements of Optics, American Optical Co. (chaps 1 and 2)									
e. The dioptric system of measurement	B			C			C		
SR: Fundamentals for the Optometric Assistant (chap 6); Bates, 1st ed., Chilton Press									
f. Refraction	A			B			C		
SR: Fundamentals for the Optometric Assistant (chap 6); Bates, 1st ed., Chilton Press; Elements of Optics (chap 2), American Optical Co.									
g. Polarization	A			B			B	NO ADVANCED COURSE	
SR: Any college physics book									
h. Absorption	A			B			B		
SR: Any college physics book									
10. OPHTHALMIC OPTICS									
a. Ophthalmic lenses									
(1) History and manufacture	A			B			B		
SR: Theory and Application of Bausch & Lomb Ophthalmic Lenses, Bausch & Lomb (1970)									
(2) Form and type	A			B			B		
SR: Professional Ophthalmic Dispensing, (chap 13), Drew, 1st ed., 1970, Professional Press; Elements of Optics American Optical Co. (chap 2)									
(3) Refractive qualities	A			B			B		
SR: Elements of Optics, American Optical Co. (chap 2)									

	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill L		
1. TASKS, KNOWLEDGES AND STUDY REFERENCES	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
10a (4) Aberrations and their correction	B/A			B			B		
SR: Professional Ophthalmic Dispensing, (chap 13), Drew, 1st ed., 1970, Professional Press									
(5) Prismatic effect (optical center)	B/A			B			B		
SR: Professional Ophthalmic Dispensing, (pp 266-274), Drew, 1st Ed., 1970, Professional Press; Fundamentals for the Optometric Assistant, (pp 193-194), Bates, 1st ed., Chilton Press									
(6) Vertex distance and effective power	B/A			B			B		
SR: Clinical Refraction, (pp 1062-1064), Borish, 3rd ed., 1970, Professional Press; Professional Ophthalmic Dispensing, (pp 394-395), Drew, 1st ed., 1970, Professional Press									
b. Interpret the prescription	2b			3c			4c		
SR: Fundamentals for the Optometric Assistant, (chap 6, 7, and 8), Bates, 1st ed., Chilton Press									
c. Transpose cylinder forms	2b			3c			4c		
SR: Fundamentals for the Optometric Assistant, (chap 6), Bates 1st ed., Chilton Press									
d. Special-purpose lenses	A			B			B		
SR: Clinical Refraction, (pp 1098-1107), Borish, 3rd ed., 1970, Professional Press									
11. ANATOMY AND PHYSIOLOGY OF THE VISUAL SYSTEM									
SR: Fundamentals for the Optometric Assistant (chap 5), Bates, 1st ed., Chilton Press									
a. The bony orbit	A			B			B	NO ADVANCED COURSE	
b. The extrinsic muscles									
(1) Origin, insertion, action and innervation	A			B			B		
(2) Ocular motility	B/A			C			C		
c. The eyeball	A			B			C		
d. The adnexa	A			B			C		
e. The visual pathway	B/A			B			C		
12. FIRST AID OF OCULAR EMERGENCIES									
SR: AFM 160-34									
a. Administer emergency first aid for nonpenetrating foreign bodies	1b/a			3c			3c		
b. Administer emergency first aid for acid and alkali burns	1b/a			3c			3c		

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill L.		
	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
12c. Administer emergency first aid for ophthalmic drug reactions	1b/a			3c			3c		
13. THE EYE AS AN OPTICAL INSTRUMENT									
SR: Fundamentals for the Optometric Assistant, (chap 6), Bates, 1st ed., Chilton Press									
a. Visual acuity	B/A			B			C		
b. Refractive states of the eye	B/A			B			C		
c. Accommodation	B/A			B			C		
d. Presbyopia	B/A			B			C		
e. Depth perception	A			B			B		
f. Color vision	A			B			C		
SR: Vision in Military Aviation, WADC TR 58-399									
14. ASSISTING THE DOCTOR OF OPTOMETRY (O. D.)									
SR: AFMs 160-1, 160-34: Fundamentals for the Optometric Assistant. (chap 1 and 10). Bates. 1st ed., Chilton Press									
a. Performing preliminary ophthalmic tests									
(1) Prepare patient	1b			3c			4c		
(2) Use the Vision Test Apparatus - Near and Distant (VTA-ND)	2b			3c			4c		
(3) Use Keystone telebinocular	2b			3c			4c	NO ADVANCED COURSE	
(4) Using the eye lane									
(a) Take distant and near visual acuity (VA)	2b			3c			4c		
(b) Perform ocular motility tests (Versions, Vergences and "Diagnostic H")	2b			3c			4c		
(5) Administer color vision tests	2b			3c			4c		
(6) Administer pupillary reflex tests	2b			3c			4c		
(7) Administer night vision test	2b/x			3c			4c		
(8) Administer stereopsis tests	2b			3c			4c		
(9) Administer accommodation tests (Prince Rule)	2b			3c			4c		
(10) Administer Worth 4-DOT test	2b			3c			4c		

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill Level		
	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
14b. Administer the eye safety program	2b/b			3c			4c		
SR: AFRs 161-31, 161-32, 161-33									
c. Classify test results for physical profile	2b			3c			4c		
SR: AFM 160-1									
15. ORDERING AND DISPENSING SPECTACLES									
SR: AFR 167-3; Fundamentals for the Optometric Assistant, (chap 8 and 9), Bates, 1st ed., Chilton Press									
a. Frame availability (types)	A			B			C		
b. Lens availability (types)	A			B			C		
c. Fitting frames to patient									
(1) Measure eye size, bridge and temple	2b			3c			4c		
(2) Take interpupillary distance (P. D.)	2b			3c			4c		
(3) Compute decentration and induced prismatic effect	2b			3c			4c		
(4) Compute segment height and inset	2b			3c			4c		
(5) Measure gas mask inserts	2b/a			3c			4c		
d. Solve fitting problems with flight equipment	1a/a			2b			3c		
e. Order spectacles	2b			3c			4c	NO ADVANCED COURSE	
f. Maintain prescription logbook	2b/a			3c			4c		
g. Authorizations required for special R_xs	A			B			C		
h. Verifying ordered prescriptions									
(1) Use the lensometer	2b			3c			4c		
(2) Use the lens clock	2b			3c			4c		
i. Performing minor spectacle repair functions									
(1) Replace temples	2b			3c			4c		
(2) Replace fronts	2b			3c			4c		
(3) Rotate lens axis	2b			3c			4c		
16. ADDITIONAL CLINICAL PROCEDURES									
a. Performing visual training procedures									
(1) Administer training procedures	1a/a			2b			3c		
(2) Record results of training	1a/a			2b			3c		

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill L		
	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
16a(3) Advise O. D. on patient progress	1a/a			2b			3c		
b. Performing contact lens procedures									
SR: Fundamentals for the Optometric Assistant, (chap 11), Bates, 1st ed., Chilton Press; Contact Lens Practice, (chap 14), Mandell, 5th ed., 1971, Chas. C. Thomas Publisher									
(1) Modification of contact lenses	A			B			C		
(2) Advise patient on contact lens care and hygiene	1a/a			2b			3c		
(3) Insert and remove lenses	1a/a			2b			3c		
c. Perform tonometric measurements	2b/1b			3c			4c		
d. Measuring visual fields									
(1) Use tangent screen	1a			2b			3c		
(2) Use perimeter	1a			2b			3c		
(3) Use Harrington-Flocks tachistoscope	1a			2b			3c		
(4) Perform confrontation fields	1a			2b			3c	NO ADVANCED COURSE	
17. ADMINISTRATIVE PROCEDURES									
a. Schedule appointments	2b/b			3c			4c		
b. Maintain medical records	2b/b			3c			4c		
c. Maintain optometric instruments	2b/b			3c			4c		
d. Use suggested referral systems	2b/b			3c			4c		
SR: AFR 10-1									

STS 912X5/C1
12 September 1975

SKT REVIEW REFERENCES

1. This attachment identifies review references for the Specialty Knowledge Test (SKT) under the Weighted Airman Promotion System (WAPS). The basic information needed for the SKT is covered in the Career Development Course (CDC). Other references are cited when the CDC requires supplementation to ensure currency and completeness of coverage or where no CDC exists. The attachment identifies the specific career field ladder by AFSCs and its associated Air Force Personnel Tests (AFPTs) by AFPT number.

2. Reference listings are limited to the basic reference. Amendments, revisions, and changes are considered a part of the basic reference. If publications are superseded or replaced by other publications, the latter should be regarded as part of the review references. If CDCs and other listed study references are in conflict, the later-dated reference takes precedence.

WAPS Cycles 77A/77B (1 Dec 75-30 Nov 76)

AFSCs: 91235/55/75 - Optometry Specialist/Technician

AFPTs: 91255/75

REVIEW REFERENCES	FOR PROMOTION TO E-5	FOR PROMOTION TO E-6/E-7
*CDC 91255	X	X
AFR 167-3		X
Bates, Fundamentals for the Optometric Assistant, (chapters 5 and 6) Chilton Press, Philadelphia, 1970, which contains procedures regarding visual testing, spectacle fitting, and other clinical topics; or any other publications that cover the above subject matter.		X
American Optical Co. Elements of Optics, (chapters 1 and 2) American Optical Co, 1964, which contains fundamentals of optics and the design and application of glass lenses; or any other publications that cover the above subject matter.		X
Borish, Clinical Refraction, Professional Press, (chapters 2, 3, 14, 15, and 26) Philadelphia, 1970, which discusses advanced and applied visual testing and prescription of ophthalmic lenses; or any other publication that covers the above subject matter.		X

*See Index of ECI study reference material for the applicable WAPS testing cycle.

POI J3ABR91235 000
(PDS Code PDW)

PLAN OF INSTRUCTION
(Technical Training)

OPTOMETRY SPECIALIST

SHEPPARD TECHNICAL TRAINING CENTER

6 October 1978 - Effective 11 September 1978 with class 780911

POI J3ABR91235 000 LIST OF CURRENT PAGES

This POI consists of 37 current pages issued as follows:

Page No.	Issue
Title	Original
A	Original
i thru ii	Original
1 thru 15	Original
16	Blank
17 thru 19	Original
20	Blank
21 thru 33	Original

DISTRIBUTION: AFMPC/SGE-1; ATC/SGE-2; AUL/LSE-1; USAF OMC/OMY-1; CCAF/AY-1; Sheppard: MES/MOT-1; MSOR-1; MSTR-1; MSOXC-11; MSDB-54

DEPARTMENT OF THE AIR FORCE
School of Health Care Sciences, USAF
Sheppard Air Force Base, Texas 76311

PLAN OF INSTRUCTION J3ABR91235 000
(PDS Code PDW)
6 October 1978

FOREWORD

1. PURPOSE. This publication is the plan of instruction (POI) when the pages shown on page A are bound into a single document. The POI prescribes the qualitative requirements for Course Number J3ABR91235 000, Optometry Specialist, in terms of criterion objectives and teaching steps presented by units of instruction and shows duration, correlation with the training standard, and support materials and guidance. When separated into units of instruction, it becomes Part I of the lesson plan. This POI was developed under the provisions of AFR 50-8, Instructional Systems Development (ISD), and ATCR 52-6, Resident Course Curricula Documentation.

2. COURSE DESIGN/DESCRIPTION. The instructional design for this course is Group/Lock Step. This 9 week course trains airmen to perform duties prescribed in AFR 39-1 for Optometry Specialist, AFSC 91235. Training includes basic ocular anatomy and physiology, basic optics, use and maintenance of optometric testing equipment, visual therapy, medical ethics, medical technology and techniques, asepsis, ocular first aid and emergency treatment. It prepares the student to (1) perform visual screening tests designed to discriminate between those who need professional attention and those who do not require this attention, (2) assist in examination and treatment of patients, (3) assist in the preparation and fitting of spectacles, (4) assist in the fitting of contact lens, (5) assist in visual training, (6) perform prescription order duties, and (7) perform related administrative duties. In addition, military training is provided on end of course appointments, predeparture safety briefing, and physical conditioning.

NOTE: For objectives in this POI which are knowledge-oriented and do not develop a skill, items on written tests for the course will serve as the required standard and condition. The standard of performance for task-oriented objectives is 100 percent unless otherwise stated. Students may use instructional material with no instructor assistance during the performance test unless otherwise stated in the objective. In addition to the instructional materials listed throughout this POI, the student uses the following dictionaries as his vocabulary needs may dictate:

Schapero, et al, Dictionary of Visual Sciences
Dorland's Medical Dictionary

The following texts may also be optionally used to supplement the Student Instructional Materials in units I-1, 2; II-1, 2; III-1, 2; IV-1; and V-2 as long as they are available:

American Optical Company, Elements of Optics
Bates, Fundamentals for the Optometric Assistant

3. REFERENCES. This plan of instruction is based on Specialty Training Standard 912X5, 3 March 1975; Change 1, 12 Sep 75; Change 2, July 76; Change 3, Aug 76; Change 4, Mar 77; Change 5, Oct 77; and Course Chart 3ABR91235, 6 October 1978.

FOR THE COMMANDER

Brian J Duffy

BRIAN J. DUFFY, Lt Col, USAF, MSC
Chief, Training Operations Division

Supersedes Plan of Instruction 3ABR91235, 8 February 1978
OPR: Department of Biomedical Sciences
DISTRIBUTION: Listed on Page A

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist

BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

1 COURSE CONTENT	2 TIME
1. Welcome and Orientation	4

- a. Course welcome, course content, and administration
- b. Course and school policies
- c. Types and uses of instructional materials
- d. Effective study procedures
- e. Conservation of training materials, resources, and energy
- f. Community College of the Air Force (CCAF) briefing
- g. Student Critique Program
- h. Safety in the training environment
- i. Testing and grading system
- j. Career ladder progression
- k. Vision care specialist

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

SIGNATURE AND DATE	SIGNATURE AND DATE

PLAN OF INSTRUCTION NUMBER	DATE	PAGE NO.
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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

SG J3ABR91235 000-I-1, Introduction to the Optometry Career Field
HO J3ABR91235 000-I-1h, Optometry Safety
Stein, Slatt, The Ophthalmic Assistant

Audiovisual Aids

FLC 13-202, The Miracle of Vision (optional)
Slide Set, Introduction (optional)

Training Methods

Lecture/Discussion (4 hrs)

Instructional Guidance

Extend welcome. Complete requisite forms. Emphasize the need to constantly improve the vision care delivery system, stress to students that AFR 39-10, states that personnel are subject to discharge for "failure to attain or maintain required job skill proficiency, either by associated inaptitude or nonapplication." Chalkboard or flipchart diagrams may be used in lieu of slide set or film at instructor's discretion, and depending on the specific applications for a particular class.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

1 COURSE CONTENT	2 TIME
2. Geometrical Optics	36
a. Given 40 mathematical problems applicable to the field of Optometry, solve 75 percent correctly within 60 minutes. Instructor assistance and reference materials are not permitted while performing the performance test. STS: 9a, 9b, 9c, 9d, 9e, 9f, 10a(5), 10a(6), 10b, 10c, 15c(1), 15c(2), 15c(3), 15h(1), 15h(2) Meas: W, P	(10)
b. Describe the characteristics of light and light waves. STS: 9a, 9c, 9d, 9e, 9f, 9g, 9h Meas: W	(3)
c. Define the laws and characteristics of reflection and refraction. STS: 9a, 9c, 9d, 9e, 9f, 9g, 9h, 10a(4) Meas: W	(5)
d. Given 10 diopter/focal length conversion problems correctly solve 8 within 50 minutes. Instructor assistance and reference materials are not permitted while performing the performance test. STS: 9c, 9e, 9f, 10a(6), 10b Meas: W, P	(8)
e. Describe refractive qualities of ophthalmic lenses. STS: 9e, 9f, 10a(2), 10a(3), 10a(4) Meas: W	(4)
f. Describe transposition of the eyewear prescription (Rx) and the derivation of the near and intermediate Rx. STS: 9b, 9e, 10a(2), 10a(3), 10b, 10c Meas: W	(6)

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR91235 000-I-2, Geometrical Optics
WS J3ABR91235 000-I-2a, Optometric Math (A and B Series)
WS J3ABR91235 000-I-2d, Diopters and Focal Lengths (A and B Series)
HO J3ABR91235 000-I, Ophthalmic Tests and Measurements, Part I

Audiovisual Aids
Slide Set, Geometrical Optics (optional)

Training Equipment
Trial Lens Case (optional)

Training Methods
Lecture/Discussion (24)
Demonstration (2 hrs)
Performance (10 hrs)

Instructional Guidance
WS J3ABR91235 000-I-2a or PLATO test will be used to determine students' ability to perform optometric math problems. Light and light waves should be related to real world phenomena familiar to the student. Terminology used in reflection/refraction should be emphasized. Ray diagrams should be deemphasized. Diopter/focal length conversion performance should be evaluated using WS J3ABR91235 000-I-2d. Demonstrate refractive qualities of ophthalmic lenses with trial lenses if possible. Practical application of transposition will be covered in II-2j. Use of slide set is optional. Chalkboard or flipchart diagrams may be used in lieu of slide set at instructor's discretion, and depending on the specific applications for a particular class. PLATO Computer Assisted Instruction (CAI) may be used.

3. Written Test and Critique 2

4. Military Training 2

   a. Physical conditioning

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE Visual Acuity and Its Correction

1 COURSE CONTENT	2 TIME
1. Visual Acuity	18
a. Describe the anatomy and physiology of the ocular tunics and media. STS: 11c, 11e, 13a, 13b, 16c Meas: W	(5)
b. Describe types of visual acuity. STS: 13a, 13b, 13c, 13d, 14a(1), 14a(2), 14a(3), 14a(4)(a) Meas: W	(2)
c. Define and describe types of ametropia. STS: 13a, 13b, 13c, 13d Meas: W	(4)
d. Using another student as a patient, and given the necessary equipment and forms, correctly measure and record the distance visual acuity of the patient using the Projectochart or wall chart and measure the near visual acuity using the nearpoint chart. When appropriate, screen the patient for ametropia and/or amblyopia using the plus lens and/or the Pinhole Test. All tests must be performed within the stardards described in SW J3ABR91235 000-II-1. STS: 13a, 13b, 13c, 13d, 14a(1), 14a(4)(a) Meas: W, P	(7)

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

HO J3ABR91235 000-II, Ophthalmic Tests and Measurements, Part II
SW J3ABR91235 000-II-1, Visual Acuity
DD Form 741, Eye Consultation
SF 88, Report of Medical Examination
SF 600, Health Record - Chronological Record of Medical Care

Audiovisual Aids

Slide Set, Visual Acuity and Its Correction (optional)

Training Equipment

Snellen Wallchart
Snellen Nearpoint Chart
Projectochart
Pinhole Test
Plus Lens Test
Occluder
Interpupillary Distance (PD) Rule

Training Methods

Lecture/Discussion (13 hrs)
Demonstration (1 hr)
Performance (4 hrs)

Multiple Instructor Requirements

1d, Equipment, Supervision (3 instructors for 5 hours)

Instructional Guidance

Differentiate between visual acuity and visual efficiency. Use of slide set is optional. Chalkboard or flipchart diagrams may be used in lieu of slide set at instructor's discretion, and depending on the specific applications for a particular class.

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PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR

COURSE TITLE Optometry Specialist

BLOCK NUMBER II

BLOCK TITLE Visual Acuity and Its Correction

1 COURSE CONTENT	2 TIME
2. Ophthalmic Lens Procurement and Verification	100
a. Explain the elements contained within an opthalmic prescription. STS: 9e, 9f, 10a(3), 10a(5), 10a(6), 10b, 10c, 10d Meas: W	(1.5)
b. Depict types of lenses available in the military. STS: 9g, 9h, 10a(1), 10a(2), 10a(3), 10d, 15b Meas: W	(1.5)
c. Depict types, styles, and parts of standard military spectacle frames. STS: 15a, 15c(1), 15c(6), 15d, 15e Meas: W	(2.5)
d. Using students as patients, and given a PD ruler, correctly measure and record the distance and near interpupillary distance on three patients to an accuracy of ± 0.5mm. STS: 14a(1), 15c(2), 15c(3), 15e Meas: W, P	(5.5)
e. Using students as patients and given a spectacle frame fitting set, correctly select a frame with appropriate eye size, bridge size, and temple length for three patients, then using that frame, measure basic multifocal heights. An accuracy of ± 2mm is required for eye size and bridge size determinations; an accuracy of ± 1/4 inch is required for temple length determinations; basic multifocal heights must be within ± 1.0mm of that measured by an instructor on any given patient. STS: 15c(1), 15c(5), 15e, 15i(1), 15i(2) Meas: W, P	(8)
f. Using a student as a patient, and given the necessary parts, tools and equipment, correctly assemble and modify within 15 minutes a standard military spectacle frame to fit the patient. STS: 15c(1), 15c(2), 15c(3), 15c(5), 15e, 15i(1), 15i(2) Meas: W, P	(5)
g. Explain fitting of ophthalmic eyewear designed for use within a gas mask or oxygen mask. STS: 15a, 15c(1), 15c(2), 15c(3), 15c(5), 15c(6), 15d, 15e, 15f, 15g Meas: W	(2)
h. Without reference, and given a lens clock or lens gauge, correctly determine the base curves of six consecutive pairs of spectacles to an accuracy of ± 0.25 diopter. STS: 9e, 10a(2), 10b, 10c, 15b, 15e, 15g, 15h(2) Meas: W, P	(5)

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i. Explain the procedures for ordering, dispensing, and recording transactions of spectacles and other corrective devices for the eyes, set forth in AFR 167-3. STS: 10a(2), 10b, 10c, 10d, 13b, 13d, 15a, 15b, 15e, 15f, 15g, Meas: W (5)

j. Using SW J3ABR91235 000-II-2 as a reference, and given accepted eye examination forms, with data, correctly complete six consecutive DD Forms 771, Eyewear Prescription, in accordance with AFR 167-3, and checklist J3ABR91235 000-II-2j. STS: 10b, 10c, 15a, 15b, 15c(3), 15c(5), 15e, 15f, 15g, 17b Meas: W, P (22)

k. Describe the information required to maintain a prescription order logbook. STS: 15e, 15f Meas: W (3)

l. Given the necessary supplies and equipment and making reference to student instructional materials, neutralize and record on checklist J3ABR91235 000-II-2l the prescriptions of 20 indexed prescription ophthalmic lenses. At least 15 of these lenses must be neutralized within ANSI Z80.1 standards. Instructor assistance is not permitted during the performance test. STS: 9e, 10a(3), 10a(5), 10b, 10c, 15h(1) Meas: W, P (18)

m. Given six consecutive pairs of selected single vision and multifocal eyewear, correctly determine all pertinent data included in checklist J3ABR91235 000-II-2n. Record data on DD Form 771-771-1. ANSI Z80.1 and AFR 167-3 will be used as standards. Use of student instructional materials is permitted during the performance test. STS: 9b, 9e, 10a(2), 10a(3), 10a(5), 10b, 10c, 10d, 15a, 15b, 15c(1), 15c(3), 15c(5), 15e, 15g, 15h(1) Meas: W, P (16)

n. Given one pair of cellulose acetate frames and one pair of aircrew frames, both containing lenses and the necessary tools and equipment, remove, remount, and realign the spectacles to within ANSI Z80.1 standards. Pertinent parts of ANSI Z80.1 standards are listed in SW J3ABR91235 000-II-2. Use of student instructional materials is permitted during the performance test. STS: 15a, 15i(1), 15i(2), 15i(3) Meas: W, P (4)

o. Given 10 problems relating to spherical equivalents correctly solve these problems with 100 percent accuracy within 20 minutes. Instructor assistance and reference materials are not permitted during the performance test. STS: 9e, 10a(3), 10b Meas: W, P (1)

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

SW J3ABR91235 000-II-2, Ophthalmic Lens Procurement and Verification
WS J3ABR91235 000-II-2h, Base Curves
WS J3ABR91235 000-II-2j, Completion of DD Form 771
WS J3ABR91235 000-II-2l, Lens Neutralization
WS J3ABR91235 000-II-2n, Spectacle Duplication
WS J3ABR91235 000-II-2p, Spherical Equivalents
HO J3ABR91235 000-II, Ophthalmic Tests and Measurements
DD Form 771, Eyewear Prescription of DD Form 771-1, Eyewear Prescription Plastic Lens
DD Form 741, Eye Consultation or SF 600, Health Record - Chronological Record of Health Care
Stein and Slatt, The Ophthalmic Assistant

Audiovisual Aids

Slide Set, Ophthalmic Lens Procurement and Verification
Videotape, Base Curves
Videotape, Lensometry

Training Equipment

Military Spectacle Frame Parts, 1 Set
Indexed Prescription Ophthalmic Lens Sets
Indexed Spectacles
Spectacle Frame Fitting Set
Optician's Tools
PD Rule
Frame Warmer
Gas Mask Fitting Set
Colmascope
Lensometer
Projection Lensometer
Lens Clock or Lens Gauge
S-7 and/or S-10 Lenses
Aircrew Frames
Aircrew Lenses

Training Methods

Lecture/Discussion (37 hrs)
Demonstration (6 hrs)
Performance (57 hrs)

Multiple Instructor Requirements

2d, Safety, Equipment, Supervision (2 instructors for 3 hours)
2e, Safety, Equipment, Supervision (3 instructors for 5 hours)
2f, Safety, Equipment, Supervision (3 instructors for 4 hours)
2h, Safety, Equipment, Supervision (3 instructors for 3 hours)
2j, Safety, Equipment, Supervision (2 instructors for 6 hours)
2j, Safety, Equipment, Supervision (3 instructors for 10 hours)

2l, Safety, Equipment, Supervision (2 instructors for 1 hour)
2l, Safety, Equipment, Supervision (3 instructors for 13 hours)
2m, Safety, Equipment, Supervision (3 instructors for 11 hours)
2n, Safety, Equipment, Supervision (3 instructors for 2 hours)

Instructional Guidance
Administer measurement test II-1 following the completion of objective 2g; administer measurement test II-2 following completion of objective 2k; and administer measurement test II-3 following completion of objective 2o. Each of the items listed in unit 2 should naturally blend into the preceding and following objectives. Relate each objective to its relative importance and frequency in the clinic. Emphasize the fact that the course is interested in accuracy of work, while the clinic is interested in both accuracy and speed. Practical application of transposition should be taught in II-2j. Practical application and computation of spherical equivalents should be taught in II-2o.

3. Military Training 6

   a. Physical Conditioning

4. Written Test and Critique 5

   a. Measurement Test and Test Critique II-1 (2)

   b. Measurement Test and Test Critique II-2 (2)

   c. Measurement Test and Test Critique II-3 (1)

30A

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist
BLOCK NUMBER III	BLOCK TITLE Assisting the Optometrist

1 COURSE CONTENT	2 TIME
1. Ocular Motility	18
a. Examine the anatomy and physiology of the ocular adnexa. STS: 1d Meas: W	(3)
b. Explain the nervous system divisions of the eye and adnexa. STS: 11d Meas: W	(2)
c. Describe the anatomy and physiology of the bony orbit and extraocular muscles. STS: 11a, 11b(1), 11b(2), 11c, 11d, 13e, 14a(2), 14a(3), 14a(4)(b) Meas: W	(2)
d. Explain ocular motility. STS: 11b(1), 11b(2), 11c, 11e, 14a(2), 14a(3), 14a(4)(a), 14a(4)(b), 14a(8), 14a(10), 16a(2) Meas: W	(4)
e. Using a student or the Strabismus Demonstrator as a patient and given necessary equipment and forms, perform the Cover Test, the Worth 4-Dot Test, and the Diagnostic H Test. Then correctly determine the presence or absence of monocular or binocular anomalies of ocular motility and record the results on Standard Form 600, Procedures must follow those listed on the appropriate task sheets in HO J3ABR91235 000-III, Part III, and results must coincide with the determination made by an instructor. If the Strabismus Demonstrator is used, the student must correctly determine five out of five presentations. STS: 11b(1), 11b(2), 11c, 11e, 14a(2), 14a(3), 14a(4)(b), 14a(8), 14a(10), 17b, 17c Meas: W, P	(7)

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30B

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR91235 000-III-1, Ocular Motility Testing
HO J3ABR91235 000-III, Ophthalmic Tests and Measurements, Part III
DD Form 741, Eye Consultation
SF 600, Health Record - Chronological Record of Medical Care

Audiovisual Aids
Slide Set, Ocular Motility
TV Cassette CDM-17, Childhood Strabismus, An Approach of Non-Ophthalmologists (optional)

Training Equipment
Occluders
Strabismus Test Demonstrator
Worth 4-Dot Targets
Anaglyph Glasses
Penlights
Prisms
Projectochart

Training Methods
Lecture/Discussion (12 hrs)
Demonstration (1 hr)
Performance (5 hrs)

Multiple Instructor Requirements
le, Supervision, Equipment (3 instructors for 5 hours)
le, Supervision, Equipment (2 instructors for 1 hour)

Instructional Guidance
Simulate muscle anomalies by use of prisms or student role playing. If the Strabismus Demonstrator is substituted for a live patient when performing the Cover Test the student will determine and record five out of five presentations correctly.

30C

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist
BLOCK NUMBER III	BLOCK TITLE Assisting the Optometrist

1 COURSE CONTENT	2 TIME
2. Miscellaneous Optometric Procedures	61.5
a. Explain selection and use of ophthalmic topical anesthetics. STS: 12a, 12c, 16c Meas: W	(1.5)
b. Describe accepted and safe procedures for instillation of ophthalmic drops. STS: 12c, 16c, 17b, 17d Meas: W	(1.5)
c. Using a student as a patient and given the necessary equipment and supplies, correctly administer an intraocular pressure measurement using a Schiotz Tonometer without injury to the patient. Results will be within 4mm of that determined by an instructor using the noncontact Tonometer. STS: 16c, 17b, 17c Meas: W, P	(12)
d. Describe the anatomy and physiology of the visual pathway. STS: 11e, 13c, 14a(6), 16d(1), 16d(2), 16d(3), 16d(4) Meas: W	(3)
e. Describe actions and uses of ophthalmodiagnostic drugs. STS: 12c, 13c, 16c Meas: W	(3)
f. Using a student as a patient and given the necessary equipment and forms, correctly administer and record direct, consensual and accommodative pupillary reflex tests. Results must be identical to those made by an instructor. STS: 11e, 13c, 14a(6) Meas: W, P	(3.5)
g. Using a student as a patient and given the necessary instruments and forms, perform appropriate visual field tests to include Brombach Perimetry, Confrontation Tests, Harrington-Flocks Tachistoscope, Autoplot Tangent Screen/Tangent Screen. Results will agree with the determinations made by an instructor. Brombach Perimeter results will define the patient's peripheral field to within ± 10 degrees of the actual value. Autoplot Tangent Screen/Tangent Screen testing will locate and plot all central field defects with a positional accuracy of ± 5 degrees of the actual value. Procedures will be in accordance with SW J3ABR91235 000-III-2 and appropriate task sheets in HO J3ABR91235 000-III, Part III. STS: 11e, 16d(1), 16d(2), 16d(3), 16d(4), 17b, 17c Meas: W, P	(16)
h. Explain emergency first aid treatment techniques in ocular trauma. STS: 11d, 12a, 12b, 12c, 17b, 17d Meas: W	(4)

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i. Describe the eye safety program and visual requirements of occupational vision. STS: 14b, 17b, 17d Meas: W (3)

j. Discuss vision screening programs. STS: 14a(1), 14a(3), 14a(4)(a), 14a(4)(b), 14a(8), 14a(10), 16c, 16d(3), 16d(4), 17a, 17b, 17c, 17d Meas: W (1)

k. Using a student as a patient, and given a keystone telebinocular and keystone visual skills charts, correctly administer visual skills tests in accordance with instructions and standards printed in SW J3ABR91235 000-III-2. STS: 11b(2), 13a, 13b, 13c, 13d, 13e, 13f, 14a(1), 14a(3), 17b, 17c, 17d Meas: W, P (6)

l. Define the knowledge required in the performance of contact lens procedures. STS: 12a, 16b(1), 16b(2), 16b(3) Meas: W (3)

m. Explain the theory and rationale of visual training procedures. STS: 11b(1), 11b(2), 13c, 14a(4)(b), 16a(1), 16a(2), 16a(3), 17b Meas: W (4)

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR91235 000-III-2, Miscellaneous Optometric Procedures
WS J3ABR91235 000-III-2g, Tangent Screen Chart
HO J3ABR91235 000-III, Ophthalmic Tests and Measurements, Part III
Visual Field Charts, Peripheral
Autoplot Charts
Harrington-Flocks Tachistoscope Charts
DD Form 741
SF 88, Report of Medical Examination
SF 600
Keystone Visual Skills Chart

Audiovisual Aids
Slide Set, Miscellaneous Optometric Procedures

Training Equipment
Corneal Anesthetic
Schiotz Tonometer
Noncontact Tonometer
Perimeter
Tangent Screen
Tachistoscope
Autoplot
Penlights

Training Equipment (Continued)
Keystone Skills Unit
Visual Field Test Targets
Brock Strings

Training Methods
Lecture/Discussion (34 hrs)
Demonstration (3.5 hrs)
Performance (24 hrs)

Multiple Instructor Requirements
2c, Safety, Equipment, Supervision (3 instructors for 9 hours)
2f, Safety, Equipment, Supervision (2 instructors for 1 hour)
2g, Safety, Equipment, Supervision (3 instructors for 12 hours)
2g, Safety, Equipment, Supervision (2 instructors for 1 hour)
2k, Safety, Equipment, Supervision (3 instructors for 3 hours)
2k, Safety, Equipment, Supervision (2 instructors for 1 hour)

Instructional Guidance

Students may confirm their Schiotz pressure findings using the noncontact tonometer if time permits. Emphasize importance of medical record entries in ocular emergencies. Administer measurement test III-1 following completion of objective 2c and administer measurement test III-2 following objective 2m. Students expressing symptoms of ocular discomfort or suspected of having corneal abrasions after Schiotz tonometry will receive slit lamp examination by the course optometrist and be referred to Ophthalmology if required. The course optometrist will be present for instillation of corneal anesthetic and performance of tonometry due to medical - legal implications.

3. Written Test and Critique 3

4. Military Training 4

a. Physical Conditioning

30F

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist
BLOCK NUMBER IV	BLOCK TITLE Vision Classification

1 COURSE CONTENT	2 TIME
1. Vision Classification	34.5
a. Given a Vision Testing Apparatus - Near and Distant (VTA-ND) and using a student as a patient correctly administer and record all VTA-ND tests in accordance with AFM 160-17. STS: 13a, 13b, 13c, 13d, 13e, 14a(1), 14a(2), 17b, 17c Meas: W, P	(6.5)
b. Using a student as a patient, and given a Verhoeff apparatus, Stereo fly, and necessary forms, accurately determine and record the presence or absence of clinical depth perception (stereopsis). Procedures will be as described in SW J3ABR91235 000-IV-1 and the results of testing must coincide with the determinations made by an instructor. STS: 13c, 13e, 14a(1), 14a(8), 17b, 17c Meas: W, P	(5)
c. Using a student as a patient and given the necessary instruments and forms, correctly administer and record the results of Pseudoisochromatic Plate, Color Threshold and Farnsworth Lantern. Procedures will be as described in SW J3ABR91235 000-IV-1 and the results will be identical with those determined by an instructor. STS: 9c, 13f, 14a(5), 17b, 17c Meas: W, P	(9)
d. Describe use and record format of red lens test. STS: 11b(2), 17b, 17c Meas: W	(1)
e. Using a student as a patient and given a prince rule, correctly measure and record amplitude of accommodation and near point of convergence. Test procedures will be as described in AFM 160-17 and test results will agree with the determinations of an instructor. STS: 11b(2), 13c, 13d, 14a(1), 14a(4)(b), 14a(9), 17b Meas: W, P	(6)
f. Given visual acuity data on 10 patients, correctly classify the E (eye) portion of the PULHESX profile to the standards described in AFR 160-43. SW J3ABR91235 000-IV-1 may be used as reference. STS: 14c, 17b Meas: W, P	(3)
g. Given necessary patient data, correctly record the information on a SF 88 and determine whether or not the patient is visually qualified for selected career fields in accordance with the standards described in AFR 160-43. STS: 13a, 13b, 13c, 13d, 13e, 13f, 14c, 17b Meas: W, P	(4)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR91235 000-IV-1, Vision Classification
WS J3ABR91235 000-IV-1f, PULHESX Profile
WS J3ABR91235 000-IV-1g, Vision Classification
HO J3ABR91235 000-IV, Ophthalmic Tests and Measurements, Part IV
AF Form 718, Color Vision Threshold Test Record
DD Form 741, Eye Consultation
SF 88, Report of Medical Examination
SF 600, Health Record - Chronological Record of Medical Care

Audiovisual Aids
Slide Set, Vision Classification (optional)

Training Equipment
VTA-ND
Verhoeff Stereopter
Stereo Fly
Pseudoisochromatic Plates
Vision Test Apparatus, Color Threshold
Farnsworth Lantern, Color Perception Testing
Prince Rule
Light, Color Perception Testing

Training Methods
Lecture/Discussion (13.5 hrs)
Demonstration (4 hrs)
Performance (17 hrs)

Multiple Instructor Requirements
1a, Safety, Equipment, Supervision (3 instructors for 5 hours)
1a, Safety, Equipment, Supervision (2 instructors for 1 hour)
1b, Safety, Equipment, Supervision (3 instructors for 2 hours)
1b, Safety, Equipment, Supervision (2 instructors for 1 hour)
1c, Safety, Equipment, Supervision (3 instructors for 4 hours)
1c, Safety, Equipment, Supervision (2 instructors for 1 hour)
1e, Safety, Equipment, Supervision (3 instructors for 3 hours)
1e, Safety, Equipment, Supervision (2 instructors for 1 hour)
1f, Supervision (2 instructors for 1 hour)
1g, Safety, Equipment, Supervision (2 instructors for 2 hours)

30H

Instructional Guidance

Since vision screening tests are of extreme importance in any optometry clinic, students should be well versed in their application. Closely supervise all practice sessions and insure students have task sheets completed. Students should be aware of AFM 160-17 and AFR 160-43. Follow standards closely. Emphasize need for accurate test determinations and proper record keeping. Use of slide set is optional. Chalkboard or flipchart diagrams may be used in lieu of slide set at instructor's discretion, and depending on the specific applications for a particular class.

2. Written Test and Critique 1.5

3. Military Training 2

   a. Physical Conditioning

30I

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist

BLOCK NUMBER V	BLOCK TITLE Clinic Management and Practicum

1 COURSE CONTENT	2 TIME
1. Chemical Warfare Defense	2
a. Explain the concept on chemical warfare operation. Meas: W	
b. Describe chemical warfare threats and agents. Meas: W	
c. Depict the medical implication of chemical warfare. Meas: W	

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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SUPPORT MATERIALS AND GUIDANCE

Audiovisual Aids
16mm Film, TS-96, Chemical Warfare

Training Methods
Lecture (0.5 hrs)
Performance (1.5 hrs)

Instructional Guidance
After viewing the film, TS-0096, the remaining chemical warfare defense training and the required measurement will be accomplished using computer assisted instruction. If the students have previously viewed film TS-0096, the showing of this film in the classroom may be omitted.

PLAN OF INSTRUCTION/LESSON PLAN PART I

30K

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist
BLOCK NUMBER V	BLOCK TITLE Clinic Management and Practicum

1 COURSE CONTENT	2 TIME
2. Fundamental Patient Administrative Practices	7.5
a. Identify the mission, organization, development, and function of the medical service and optometry clinic and indicate the duties, career ladder progression and educational opportunities of its enlisted members. STS: 1a, 1b, 1c(1), 1c(2), 1d Meas: W	(3.5)
b. Depict proper professional and patient relationships. STS: 5a, 5b, 5c Meas: W	(1)
c. Describe appointment systems, maintenance of appointment logbook, patient inprocessing, and telephone courtesy. STS: 8a(3), 14a(1), 17a, 17b Meas: W	(3)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

SW J3ABR91235 000-V-2, Fundamental Patient Administrative Practices
HO 9XXXX XXX, Anyone You Know?

Audiovisual Aids

Slide Set, Fundamental Patient Administrative Practices (optional)

Training Methods

Lecture/Discussion (7.5 hrs)

Instructional Guidance

Use of slide set is optional. Chalkboard or flipchart diagrams may be used in lieu of slide set at instructor's discretion, and depending on the specific applications for a particular class. PLATO may also be used.

PLAN OF INSTRUCTION/LESSON PLAN PART I

30M

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist
BLOCK NUMBER V	BLOCK TITLE Clinic Management and Practicum

1 COURSE CONTENT	2 TIME
3. Publications and Supply Management	5
a. Identify the rationale and uses of indexes for AF and commercial publications. STS: 6a Meas: W	(2)
b. Identify common medical materiel procedures. STS: 7a, 7b, 7c, 7d, 7e, 7g, 7h, 7k Meas: W	(3)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR91235 000-V-3, Publications and Supply Management

Training Methods
Lecture/Discussion (5 hrs)

300

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist
BLOCK NUMBER V	BLOCK TITLE Clinic Management and Practicum

1 COURSE CONTENT	2 TIME
4. Communications and Operations Security	2

a. Identify information as classified, unclassified, or of possible intelligence value and state the definitions of selected terms used in the classification of material. STS: 3a(1), 3a(2) Meas: W

b. Identify precautions used in handling/transmitting classified information. STS: 3a(3), 3a(4) Meas: W

c. Identify specific operations security (OPSEC) vulnerabilities of this specialty. STS: 3b(6) Meas: W

d. Describe patient data confidentiality and conflict of interest. STS: 5a, 5b, 5c Meas: W

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR9XXXX 00X, Communications Security
SW J3ABR91235 000-V-4, Operational Security, Patient Confidentiality and Conflict of Interest

Training Methods
Lecture/Discussion (2 hrs)

Instructional Guidance
Assist students to identify key points described in SW J3ABR9XXXX 00X and SW J3ABR91235 000-V-4. PLATO may be used.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist

BLOCK NUMBER V	BLOCK TITLE Clinic Management and Practicum

1 COURSE CONTENT	2 TIME
5. Clinic Cleanliness and Safety	7
a. Identify principles of general safety and itemize facts and terms pertaining to accident reporting. STS: 4a, 4b, Meas: W	(.5)
b. Explain the importance of accurate and complete medical record entries following accidental injury. STS: 4c, 8a(3), 17b Meas: W	(.5)
c. Given necessary supplies and equipment and exercising appropriate safety precautions, administer proper order, cleanliness, and asepsis to a mock-up eye clinic without damaging instruments, equipment, or other contents. STS: 1c(2), 4b, 5a, 17c Meas: W, P	(6)

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW J3ABR91235 000-V-5, Clinic Cleanliness and Safety

Audiovisual Aids
Slide Set, Accident Prevention on the Job (optional)

Training Equipment
Normal Janitorial Equipment and Supplies

Training Methods
Lecture/Discussion (2 hrs)
Performance (5 hrs)

Multiple Instructor Requirements
5c, Supervision (3 instructors for 5 hours)

Instructional Guidance
Depict selected ophthalmic instruments and their proper maintenance. Use of slide set is optional. Chalkboard or flipchart diagrams may be used in lieu of slide set at instructor's discretion, and depending on the specific applications for a particular class.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Optometry Specialist

BLOCK NUMBER V	BLOCK TITLE Clinic Management and Practicum

1 COURSE CONTENT	2 TIME
6. Practicum	25

a. Assigned an optometry specialist role-playing situation in the SHCS or Hospital Optometry Clinic, correctly perform under supervision, duties and responsibilities required for a 3 skill level optometry specialist. Duties performed are based on patient requirements in the clinic during the training period and on checklist J3ABR91235 000-V-6a. STS: 1c(2), 4b, 5a, 5b, 5c, 10b, 10c, 14a(1), 14a(2), 14a(3), 14a(4)(a), 14a(4)(b), 14a(5), 14a(6), 14a(8), 14a(9), 14a(10), 15c(1), 15c(2), 15c(3), 15c(5), 15c(6), 15d, 15e, 15f, 15g, 15h(1), 15h(2), 15i(1), 15i(2), 15i(3), 16c, 16d(1), 16d(2), 17a, 17b, 17c, 17d Meas: W, P

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
HO J3ABR91235 000-I thru IV, Ophthalmic Tests and Measurements
SW J3ABR91235 000-V-6, Clinic Practicum
WS J3ABR91235 000-III-2g, Tangent Screen Chart
WS J3ABR91235 000-V-6a Part I, USAF-CTT
WS J3ABR91235 000-V-6a Part 2, PULHESX Profile
WS J3ABR91235 000-V-6a Part 3, Spherical Equivalents
WS J3ABR91235 000-V-6a Part 4, Transposition
WS J3ABR91235 000-V-6a Part 5, Bifocal to Near Rx
WS J3ABR91235 000-V-6a Part 7, Verification of Prescriptions
AD Form 718, Color Vision Threshold Test Record
DD Form 741, Eye Consultation
SF 88, Report of Medical Examination
SF 513, Clinical Record - Consultation Sheet
SF 600, Health Record - Chronological Record of Medical Care
Autoplot Charts
Harrington-Flocks Tachistoscope Charts
Keystone Skill Charts
SW J3ABR91235 000-V-6a, Occupational Vision Program

Training Equipment
Keystone Skills Unit
VTA-ND
Occluder
Autoplot
Farnsworth Lantern
Perimeter
Tangent Screen
Tonometer
PD Rule
Pseudoisochromatic Plates
Lensometer
Opticians' Tools
Projectochart
Frame Warmer
Pinhole Disc
Penlight
Stereo Fly
Verhoeff Stereopter
Prince Rule
Worth 4-Dot Test Red Lens Test
Color Threshold Test
Harrington-Flocks Test
Lens Gauge
Frame Fitting Set
Assorted S-10 or Aircrew Frame Parts

Training Methods
Performance (25 hrs)

Multiple Instructor Requirements
6a, Safety, Equipment, Supervision (3 instructors for 25 hours)

Instructional Guidance
Using the whole-part-whole concept, check each student's ability to appropriately integrate various practical combinations of all tasks and knowledge previously taught. The practicum will be accomplished with uniform monitoring of student performance. During the practicum the students will normally be divided into groups so that each student may be provided a minimum of one day of experience at the Sheppard Regional Hospital eye clinic. At least one course instructor will accompany each student group. Additional assistance within the hospital eye clinic will be rendered as needed by the chief of optometry, or his designated representatives. In order to permit time to answer class critiques, it is permissible to conduct the class critique during the first day of the practicum instead of the last day of the course. Student duties will include but not be limited to the following tasks and criterion rechecks: Preparation of DD Form 741 and SF 600, obtaining a valid case history, obtaining both literate and illiterate visual acuities, usage of the pinhole and plus lens screening tests, performing cover tests, diagnostic H, accommodation NPC and Worth 4-Dot, measuring stereopsis using the stereo fly and Verhoeff devices, obtaining pupillary reflexes, testing color vision using the VTS-CV, scoring the results of the USAF Color Threshold Tester (CTT), measuring central and peripheral visual fields, using the tangent screen/autoplot and Brombach perimeter; using both the Keystone and VTA-ND as vision screening devices, classifying PULHESX profiles, determining the spherical equivalent of lenses, transposing ophthalmic Rxs, converting from bifocal to near Rx, determining whether or not ordered glasses meet ANSI standards, measuring PD and multifocal height and adjusting a frame. All conditions and standards will comply with original criterion objectives on these subjects, although the number of performance items for each individual recheck may be less than in the original C.O. due to time limitations.

7. Written Test and Critique	1
8. Course Critique and Graduation	1
9. Military Training	
a. Physical Conditioning	2
b. End of Course Appointments; End of Course Appointments	10

LESSON PLAN (Part I, General)

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APPROVAL OFFICE AND DATE MSPB Wilson [illegible] 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Mathematics Applicable to Optometry

LESSON DURATION

CLASSROOM /Laboratory 5 hrs/0 hrs	Complementary 0 hrs	TOTAL 5 hrs

POI REFERENCE

PAGE NUMBER 2	PAGE DATE 25 June 1975	PARAGRAPH 3A

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	29 Aug 75		
	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW 3ABR91235-I-3

CRITERION OBJECTIVES AND TEACHING STEPS

I-3a. Explain mathematics applicable to the field of optometry.

(Teaching steps are listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Characteristics of Light

LESSON DURATION		
CLASSROOM/Laboratory 3 hrs/0 hrs	Complementary 0 Hrs	TOTAL 3 hrs

POI REFERENCE		
PAGE NUMBER 2	PAGE DATE 25 June 1975	PARAGRAPH 3B

STS/CTS REFERENCE	
NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	29 Aug 75		
	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW 3ABR91235-I-3 Elements of Optics Slide Set, Light

CRITERION OBJECTIVES AND TEACHING STEPS

I-3b. Describe the characteristics of light.

I-3c. Explain the relationship of wavelength, amplitude, frequency, and velocity of light waves.

(Teaching steps are listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSUB Wilson 19 AUG 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Reflection

LESSON DURATION

CLASSROOM /Laboratory 1 hr/0 hrs	Complementary 0 hrs	TOTAL 1 hr

POI REFERENCE

PAGE NUMBER 3	PAGE DATE 25 June 1975	PARAGRAPH 3 d

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	29 Aug 75		
	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AID AND UNCLASSIFIED MATERIAL
NA	NA	NA	Slide Set, Light SW 3ABR91235-I-3 Elements of Optics

CRITERION OBJECTIVES AND TEACHING STEPS

I-3d. Define the laws and characteristics of reflection.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson [illegible]	INSTRUCTOR
COURSE NUMBER 3ABR91236	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Refraction

LESSON DURATION

CLASSROOM / Laboratory 4 hrs/0 hrs	Complementary 0 hrs	TOTAL 4 hrs

POI REFERENCE

PAGE NUMBER 3	PAGE DATE 25 June 1975	PARAGRAPH 3E

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	24 Aug 75		
	09 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Optical Bench (12) Laser Optical Teaching Kit 12) Mirrors, Prisms, and Lenses (12) Glass Tank & Dye(12) Lens Clock (3)	NA	NA	SW3ABR91235-I-3 Elements of Optics Fundamentals for the Optometric Assistant Slide Set, Light

CRITERION OBJECTIVES AND TEACHING STEPS

I-3e. Describe the laws and characteristics of refraction.

(Teaching steps are listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 19 AUG 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Diopters and Focal Lengths

LESSON DURATION

CLASSROOM /Laboratory	Complementary	TOTAL
4 hrs/0 hrs	0 hrs	4 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
3	25 June 1975	3f

STS/CTS REFERENCE

NUMBER	DATE
STS 91335	3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
[illegible]	29 Aug 75		
[illegible]	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	3ABR91235-I-3 Elements of Optics Slide Set, Light

CRITERION OBJECTIVES AND TEACHING STEPS

I-3f. Explain the use of formulae to convert diopters and focal lengths.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 19 [illegible]	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Absorption and Polarization

LESSON DURATION

CLASSROOM/Laboratory 1 hr/0 hrs	Complementary 0 hrs	TOTAL 1 hrs

POI REFERENCE

PAGE NUMBER 3	PAGE DATE 25 June 1975	PARAGRAPH 3g

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	29 Aug 75		
	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Polarizing Material (12)	NA	NA	SW3ABR91235-I-3 Slide Set, Light

CRITERION OBJECTIVES AND TEACHING STEPS

I-3g. Examine the characteristics of absorption and polarization.

(Teaching steps are listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDE Wilson 19 AUG 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Manufacture, Forms and Types of Ophthalmic Lenses

LESSON DURATION

CLASSROOM /Laboratory	Complementary	TOTAL
2 hrs/0 hrs	0 hrs	2 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
4	25 June 1975	34 A

STS/CTS REFERENCE

NUMBER	DATE
STS 912X5	3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	29 Aug 75		
	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR91235-I-4 Slide Set, Ophthalmic Optics

CRITERION OBJECTIVES AND TEACHING STEPS

I-4a. Describe manufacture, forms and types of ophthalmic lenses.

(Teaching steps are listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 19 [illegible]	INSTRUCTOR
COURSE NUMBER 3 BR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER 1	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Refractive Qualities of Ophthalmic Lenses

LESSON DURATION

CLASSROOM/Laboratory 4 hrs/0hrs	0 hrs	TOTAL 4 hrs

POI REFERENCE

PAGE NUMBER 4	PAGE DATE 25 June 1975	PARAGRAPH 4 B

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	29 Aug 75		
	7 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Optical Bench (12) Lens (1) Laser Optical Teaching Kit (12)	NA	NA	SW3ABR91235-I-4 Elements of Optics

CRITERION OBJECTIVES AND TEACHING STEPS

I-4b. Describe refractive qualities of ophthalmic lenses.

(Teaching steps are listed in Part II)

ATC FORM AUG 2 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 1^ -	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Prismatic Effect of an Ophthalmic Lens

LESSON DURATION

CLASSROOM/Laboratory 2 hrs/1 hr	Complementary 0 hrs	TOTAL 3 hrs

POI REFERENCE

PAGE NUMBER 4	PAGE DATE 25 June 1975	PARAGRAPH 4 c

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	29 Aug 75		
	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Prism (1)	NA	NA	SW3ABR91235-I-4

CRITERION OBJECTIVES AND TEACHING STEPS

I-4c. Given the Prentice formula for decentration, calculate prismatic effect of an ophthalmic lens to an accuracy of ± 0.25 prism diopters.

(Teaching steps listed in Part II)

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 19 AUG 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Vertex/Effective Power

LESSON DURATION

CLASSROOM/Laboratory	Complementary	TOTAL
1 hr/0 hrs	0 hrs	1 hr

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
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STS/CTS REFERENCE

NUMBER	DATE
STS 91235	3 March 1975

SUPERVISOR APPROVAL

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	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR91235-1-4 Slide Set, Ophthalmic Optics

CRITERION OBJECTIVES AND TEACHING STEPS

I-4d. Explain the relationship between vertex distance and the vertex/effective power of ophthalmic lenses.

(Teaching steps are listed in Part II)

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDG Wilson [illegible] 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Aberrations

LESSON DURATION

CLASSROOM /Laboratory 1 hr/0 hrs	Complementary 0 hrs	TOTAL 1 hr

POI REFERENCE

PAGE NUMBER 4	PAGE DATE 25 June 1975	PARAGRAPH 4 e

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	29 Aug 75		
	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR91235-I-4 Slide Set, Ophthalmic Optics

CRITERION OBJECTIVES AND TEACHING STEPS

I-4e. Depict aberrations inherent in ophthalmic lenses.

(Teaching steps listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE [illegible] B Wilson 19 AUG 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
The Ophthalmic Prescription

LESSON DURATION

CLASSROOM /Laboratory	Complementary	TOTAL
2 hrs/0 hrs	0 hrs	2 Hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
4	25 June 1975	4 f

STS/CTS REFERENCE

NUMBER	DATE
STS 912X5	3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
[illegible] Jr.	29 Aug 75		
[illegible]	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR91235-I-4 Slide Set, Ophthalmic Optics Fundamentals for the Optometric Assistant

CRITERION OBJECTIVES AND TEACHING STEPS

I-4f. Explain the elements contained within an ophthalmic prescription.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Transposition

LESSON DURATION

CLASSROOM/Laboratory 3 hrs/1 hr	Complementary 0 hrs	TOTAL 4 hrs

POI REFERENCE

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SIGNATURE	DATE	SIGNATURE	DATE
	24 Aug 75		
	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR91235-I-4 Slide Set, Ophthalmic Optics Fundamentals for the Optometric Assistant

CRITERION OBJECTIVES AND TEACHING STEPS

I-4g. Given a list of ophthalmic lens prescriptions, and instructor assistance, transpose the spherocylinder form of each prescription so that it corresponds to the requirements for ordering spectacles set forth in AFR 167-3.

(Teaching steps are listed in Part II)

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APPROVAL OFFICE AND DATE MSDB Wilson	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Special Purpose Lenses

LESSON DURATION

CLASSROOM/Laboratory 1 hr/0 hrs	Complementary 0 hrs	TOTAL 1 hr

POI REFERENCE

PAGE NUMBER 4	PAGE DATE 25 June 1975	PARAGRAPH 4h

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SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	24 Aug 75		
	9 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Colmascope (12) Lens (1)	NA	NA	SW 3ABR91235-I-4 Slide Set, Ophthalmic Optics Fundamentals for the Optometric Assistant

CRITERION OBJECTIVES AND TEACHING STEPS

I-4h. Describe special purpose lenses.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSRB Wilson 19 AUG 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER I	BLOCK TITLE Introduction and Basic Optics

LESSON TITLE
Professional and Patient Relationships

LESSON DURATION

CLASSROOM/Laboratory	Complementary	TOTAL
1 hr/0hrs	0 hrs	1 hr

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
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STS/CTS REFERENCE

NUMBER	DATE
STS 912X5	3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	24 Aug 75		
	7 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR91235-I-5 Fundamentals for the Optometric Assistant

CRITERION OBJECTIVES AND TEACHING STEPS

I-5a. Depict proper professional and patient relationships.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

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STUDY GUIDE AND WORKBOOK

3ABR91235-I

Technical Training

Optometry Specialist

INTRODUCTION AND BASIC OPTICS

BLOCK I

October 1975

10-7

SCHOOL OF HEALTH CARE SCIENCES, USAF
Department of Biomedical Sciences
Sheppard Air Force Base, Texas 76311

Designed For ATC Course Use

DO NOT USE ON THE JOB

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This supersedes SW 3ABR91235-I, August 1974.

MODIFICATIONS

Pages 1-24 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

GEOMETRICAL OPTICS

OBJECTIVES

Upon completion of this study guide and workbook you will be able to:

1. Solve mathematical problems applicable to the field of optometry.

2. Describe the characteristics of light.

3. Explain the relationship of wavelength, amplitude, frequency and velocity of light waves.

4. Define the laws and characteristics of reflection.

5. Describe the laws and characteristics of refraction.

6. Convert between diopters and focal lengths.

7. Describe the characteristics of absorption and polarization.

INTRODUCTION

Before we get into the discussion of light, lenses, mirrors, and images, it would be best to review some mathematics and systems of measurement. Optics is totally dependent on mathematics because without math all optical devices would be a matter of guesswork. Obviously, guesswork doesn't quite make it in an age that demands accuracy. We therefore need a good math foundation before we can effectively work with optics.

INFORMATION

MATHEMATICS REVIEW

We'll begin the math review with a basic concept that you will be using many times everday in an optometry clinic - algebraic addition of numbers

Algebraic Addition

Algebraic addition is very simply combining two or more numbers together. If you always think of algebraic addition in terms of dollars and cents you probably won't make any mistakes. It's really amazing that people who are terrible in math always seem to know their bank balance or how much change they should get back from a purchase. Throughout this section the examples will be explained mathematically and where possible, monetarily.

ALGEBRAIC ADDITION OF TWO PLUS NUMBERS. Algebraic addition of two plus (+) numbers will always give an answer that is plus. You quite simply add the numbers together and give the answer a plus (+) sign.

EXAMPLE 1: $\begin{array}{r} +2.50 \\ \underline{+1.75} \\ +4.25 \end{array}$ or $+2.50 + 1.75 = +4.25$

Monetarily speaking, if you have (+) \$2.50 and you are given (+) \$1.75, how much do you have all told? \$4.25 to the good or plus.

EXAMPLE 2: +12.00 or 12.00 + 5.75 = +17.75

$$\begin{array}{r} +12.00 \\ +\ 5.75 \\ \hline +17.75 \end{array}$$

In money terms, if you have (+) $12.00 in your bank balance and you receive (+) a check for $5.75 your new balance would be $17.75 to the good or plus.

ALGEBRAIC ADDITION OF TOO MINUS (-) NUMBERS. Algebraic addition of two minus numbers will always give an answer that is minus. You ADD the two numbers together and give the answer a minus (-) sign.

EXAMPLE 1: -2.50 or -2.50 - 1.75 = -4.25

$$\begin{array}{r} -2.50 \\ -1.75 \\ \hline -4.25 \end{array}$$

In terms of money, let us say that you owe (-) a friend $2.50 and you borrow (-) another $1.75, you then owe him (-) $4.25.

EXAMPLE 2:

$$\begin{array}{r} -12.50 \\ -\ 9.50 \\ \hline -22.00 \end{array}$$

Let us say that in the first hand of a poker game you lose (-) $12.50 and the second hand you lose (-) $9.50. You are then $22.00 in the hole (-) - and you'd better start playing before you lose your shirt.

ALGEBRAIC ADDITION OF A PLUS AND A MINUS NUMBER. Combining a plus and a minus number together will give the same sign in the answer as the sign of the larger number. You take the difference between the two numbers by subtracting the smaller number from the larger.

EXAMPLE 1: +12.50 - 9.50 = +3.00 or

$$\begin{array}{r} +12.50 \\ -\ 9.50 \\ \hline +\ 3.00 \end{array}$$

In money terms, if you have (+) $12.50 in your bank balance and you write a check to pay a bill (-) for $9.50 you'll still have (+) $3.00 in your account.

EXAMPLE 2: +7.50 - 9.00 = -1.50 or

$$\begin{array}{r} -9.00 \\ +7.50 \\ \hline -1.50 \end{array}$$

Let us suppose that in the first hand of our poker game you lose (-) $9.00 and in the second hand you win (+) $7.50, your standing after two hands is then $1.50 in the hole or minus.

EXERCISE 2

Algebraically add the following numbers

1. +2.75 + 6.75 =
2. -13.00 + 15.25 =
3. -10.25 - 8.25 =
4. +1.75 - 1.25 =
5. +14.50 + 2.25 =
6. - 2.75 - 22.25 =

Multiplication and Division of Decimals

A decimal number is just a whole number and a fraction written together in decimal form. Any multiplication or division by 10, 100, 1000, etc. simply moves the decimal place to the left or right. For example, multiplying a decimal by 10 would move the decimal point 1 place to the right, or dividing by 100 (10 x 10) would move the decimal point 2 places to the left.

MULTIPLICATION OF DECIMALS. Decimals are multiplied exactly like whole numbers and then the decimal point is added. For example, you would multiply 25 x 25 in this way:

$$\begin{array}{r} 25 \\ \underline{\times 25} \\ 125 \\ \underline{50} \\ 625 \end{array} \quad \begin{array}{c} \text{and } 2.5 \times 2.5 \\ \text{like this} \end{array} \quad \begin{array}{r} 2.5 \\ \underline{2.5} \\ 125 \\ \underline{50} \\ 6.25 \end{array}$$

The number of decimal places in a decimal is the number of digits (numbers) to the RIGHT of the decimal point. The number of decimal places in the product (answer) of a multiplication is the SUM total of the decimal places in the numbers that were multiplied. For example, there are 2 decimal places in 140.21 and 3 in 14.021, therefore, there would be 5 decimal places in the product of those two numbers if they were multiplied.

Zeros written to the right of a decimal point with no number other than zero to their right may be dropped in most multiplications. Thus 4.20 may be written 4.2, but zeros to the right of the decimal point WITH NUMBERS OTHER THAN ZERO TO THEIR RIGHT CANNOT BE DROPPED, without changing the value of the number. Thus you cannot drop the zero in the number 6.105.

Zeros to the left of a decimal point with no number other than zero to their left are added only to make it very clear that the number is a decimal and may be dropped when you multiply. Thus 0.4 is exactly the same as .4 and 0.23 is the same as .23.

EXAMPLE 1: 4.32 x 2.10

$$\begin{array}{r} 4.32 \\ \underline{2.10} \\ 4320 \\ \underline{86400} \\ 9.0720 \end{array}$$

Notice that the 4 decimal places in the answer are counted from right to left.

EXAMPLE 2: 1600.0 x 0.04

$$\begin{array}{r} 1600.0 \\ \underline{0.04} \\ 64.0000 \end{array}$$

ANSWER: 64.0 or 64

DIVISION OF DECIMALS. Divisions may be written in the form $\frac{a}{b} = c$ or $a \div b = c$ or $\begin{array}{r} c \\ b\overline{)a} \end{array}$ where a is the DIVIDEND, b is the DIVISOR, and c is the QUOTIENT. As with multiplication, you divide decimals exactly like you do whole numbers and then you find the decimal place. For example: dividing 126 by 6 gives 21 as an answer.

$$\begin{array}{r} 21 \\ 6\overline{)126} \end{array}$$

and dividing 12.6 by 6 gives the answer 2.1

$$\begin{array}{r} 2.1 \\ 6\overline{)12.6} \end{array}$$

Notice that the decimal point in the quotient (answer) is directly above the decimal point in the dividend.

Anytime there is a space or a number of spaces between the decimal point and the first number of the quotient, you must add zeros to complete your answer. Thus in $\overset{.\ 31}{8\overline{).248}}$ you must add a zero after the decimal point but before the three. As a result the problem and correct answer would look like this: $\overset{.031}{8\overline{).248}}$

To carry out a division as far as necessary you must often add zeros to the dividend. As we have seen before this does not change the value of the number. Thus, in $.9/2 = 2\overline{).9}$ it is necessary to add a zero to .9 to produce $\overset{.45}{2\overline{).90}}$.

When the divisor is a decimal you may change it to a whole number by moving the decimal point to the RIGHT. When the decimal point is moved in the divisor, it must be moved the same number of places in the dividend. If you move the decimal two places in the divisor, you must also move it two places in the dividend. For example:

$$\frac{0.88}{0.2} = .2\overline{).88}$$

We must move the decimal in both divisor and dividend, one place to the right. This then gives us $\overset{4.4}{2.0\overline{)8.8}}$ as a result. When the divisor is a whole number we just divide like whole numbers.

EXERCISE 3

Multiply or divide the following

The answers to questions 1-4 may be found in the back of this SW.

1. $0.19 \times 0.20 =$
2. $0.034 \times 0.025 =$
3. $12.48 \div 8.0 =$
4. $0.008 \div 800.0 =$
5. $4.12 \times 5.75 =$
6. $0.0012 \div .002 =$
7. $0.890 \times 6.00 =$
8. $\frac{0.800}{8.000} =$

Converting Fractions to Decimals

Fractions can be both common fractions and DECIMAL fractions. For example: 2/5 is a common fraction, and $\frac{1.1}{2.2}$ is a decimal fraction. The number above the dividing line in a fraction is the NUMERATOR. The number BELOW the dividing line in a fraction is the DENOMINATOR. A common fraction or decimal fraction may be converted to a decimal by dividing the numerator by the denominator. For example; $\frac{1}{2} = 2\overline{)1} = 0.5$

or $\frac{5.0}{0.2} = \begin{array}{r} 25.0 \\ 0.2\overline{)5.00} \end{array}$

EXERCISE 4

Convert the following to decimals.

Answers for questions 1-3 may be found in the back of this SW.

1. 1/4 =
2. 7/8 =
3. 3/4 =
4. 8/5 =
5. $\frac{8.96}{1.40} =$
6. $\frac{1.90}{0.04} =$

Solving for an Unknown in an Algebraic Equation

A simple algebraic equation has an unknown quantity symbolized by a letter. For example, 2N = 8 is a simple algebraic equation. In an equation such as this, the unknown must be isolated on one side of the equation. You may do anything to isolate the unknown, just make sure that you do the same thing to BOTH sides of the equation. In 2N = 8, you can divide both sides of the equation by two in order to isolate N. This gives

$\frac{2N}{2} = \frac{8}{2}$ then $\frac{\cancel{2}N}{\cancel{2}} = \frac{\cancel{8}^{4}}{\cancel{2}}$ leaving us N=4

Remember this rule: Whenever you do something to one side of an equation, you must do the same thing to the other side.

We have just worked the simplest type of algebraic equation. Now we will solve one that is more difficult, 2N + 4 = 16. Again, we need to isolate N on one side of the equation. In order to get N by itself, we first subtract 4 from both sides of the equation. Here is what we get:

$$\begin{aligned} 2N + 4 - 4 &= 16 - 4 \\ 2N &= 12 \end{aligned}$$

As you can see, we subtracted 4 from both sides because we wanted to eliminate the 4 on the left side of the equation. Now we have a simple equation like the one you just learned how to solve.

$\frac{2N}{2} = \frac{12}{2}$ then $\frac{\cancel{2}N}{\cancel{2}} = \frac{\cancel{12}^{6}}{\cancel{2}}$ leaving us N=6

To isolate an unknown you may add, subtract, multiply or divide by any number as long as you do the same to both sides. It is easiest to add or subtract first and then multiply or divide to isolate an unknown.

EXERCISE 5

Solve for the unknown in the following equations.

Answers for questions 1-3 may be found in the back of this SW.

1. $3X = 12$ $X =$

2. $4X = 20$ $X =$

3. $9y = 27$ $y =$

4. $4X - 10 = 26$ $X =$

5. $9y - 13 = 50$ $y =$

6. $12X + 21 = 165$ $X =$

Solving for an unknown in A Proportion

Problems involving proportions are solved in basically the same fashion as solving for an unknown in a simple algebraic equation. Here is an example of a proportion:

$$\frac{2}{3} = \frac{4}{X}$$

By writing a proportion in this way we are saying that 2 is to 3 as 4 is to X. To solve this proportion simply CROSS MULTIPLY, or multiply the figures that are diagonally opposite. In the case $\frac{2}{3} = \frac{4}{X}$, 2 is diagonally opposite X and 3 is diagonally opposite 4. Cross multiplying, we get $2 \times X = 4 \times 3$ or $2X = 12$. Then we just solve for X

$\frac{\cancel{2}X}{\cancel{2}} = \frac{\cancel{12}^{6}}{\cancel{2}}$ leaving $X = 6$.

That's all there is to it. You will only have one unknown in a proportion, and by CROSS MULTIPLYING you can turn any proportion into a simple algebraic equation that you already known how to solve. Here are some more examples:

EXAMPLE 1: $\frac{14}{24} = \frac{X}{48}$

$$\begin{aligned} 24 \times X &= 48 \times 14 \\ 24X &= 672 \\ X &= 28 \end{aligned}$$

EXAMPLE 2: $\frac{X}{14} = \frac{3}{7}$

$$\begin{aligned} X \times 7 &= 3 \times 14 \\ 7X &= 42 \\ X &= 6 \end{aligned}$$

EXERCISE 6

Solve for the unknown in the following proportions. Carry your answers out to one decimal place.

Answers for questions 1 & 2 may be found in the back of this SW.

1. $\frac{5}{X} = \frac{7}{35}$ $X =$

2. $\frac{3}{8} = \frac{14}{X}$ $X =$

3. $\frac{7}{30} = \frac{X}{21}$ $X =$

4. $\frac{X}{16} = \frac{8}{42}$ X =

Powers

A power is written in the format X^3. The X is the BASE number and the superscript (3) is the EXPONENT or power. X^3 means X will be multiplied by itself the number of times indicated by the exponent, in this case 3 times. This gives us $X^3 = X \times X \times X$

Here are some more examples:

$3^2 = 3 \times 3$

$5^6 = 5 \times 5 \times 5 \times 5 \times 5 \times 5$

$z^4 = z \times z \times z \times z$

$10^2 = 10 \times 10$

$10^1 = 10$

Powers of Ten

Large numbers, particularly ones with many zeros, are often written as small numbers times a power of ten. For example $200{,}000 = 2 \times 100{,}000 = 2 \times 10^5$.

To get used to working with this we will first work with the plus powers of ten. You may already know that multiplying a given number by ten just moves the decimal point one place to the right, e.g., $1.9 \times 10 = 19.0$. Likewise if you multiply by 10 three (3) times (10 x 10 x 10) you are in actual fact moving the decimal place 3 places to the right. $1.9 \times 10^3 = 1.9 \times 10 \times 10 \times 10 = 1\underbrace{900}_{\text{3 places}}.$. So if you multiply a number by a power of ten, just look at the exponent and if it is a plus exponent move the decimal that number of places to the right.

If however, the power of ten is minus e.g. 10^{-2} it means to divide the number by 10^2. This may be easily written as $10^{-2} = \frac{1}{10^2}$. As far as the effect of a minus exponent on a decimal number, it is worked the same as plus exponents, except that you move the decimal place to the left. For example: $1.9 \times 10^{-2} = 0.\underbrace{01}_{\text{2 places}}9$

Here are some more examples of plus and minus exponents:

1. $4.5 \times 10^2 = 450$ (2 places to the right)

2. $3.6 \times 10^{-3} = 0.0036$ (3 places to the left)

3. $4.83 \times 10^5 = 483000.0$ (5 places to the right)

4. $4.83 \times 10^{-5} = .0000483$ (5 places to the left)

Let's continue on to reducing a large number to a power of ten. Since the advent of computers, calculators and the slide rule a method of writing large numbers has evolved called SCIENTIFIC NOTATION. It consists of a basic number between 1 and 10 times a power of ten. Let us take the number 483,000. The number between 1 and 10 is 4.83 and it must be multiplied by 10^5 so that the value of the original number isn't changed. So combined together $483{,}000 = 4.83 \times 10^5$. The easiest way to get Scientific Notation is to find your number between 1 and 10 then determine what power of ten you can multiply by to give you the number you started with, remembering that multiplying by plus exponents moves the decimal place to the right and minus exponents move the decimal place to the left. Thus 0.000483 gives a number between 1 and 10 of 4.83. If we then multiply 4.83 by 10^{-4} we will still have 0.000483 but it will be written in the form 4.83×10^{-4}.

To multiply numbers written as powers of ten then becomes quite simple, you MULTIPLY THE NUMBERS (ignoring the tens) and ADD the EXPONENTS of the tens thus
$[2 \times 10^3]\ [3 \times 10^4] = 6 \times 10^7$
and $[4 \times 10^2]\ [2 \times 10^3] = 8 \times 10^5$
NOTE: The parentheses mean multiply.

To divide powers of ten you DIVIDE the numbers (again ignoring the tens) and SUBTRACT the EXPONENTS. Thus $\frac{8 \times 10^4}{2 \times 10^2} = \frac{8}{2} \times 10^{4-2} = 4 \times 10^2$

$$\text{and } \frac{8 \times 10^4}{4 \times 10^5} = 8/4 \times 10^{4-5} = 2 \times 10^{-1}$$

EXERCISE 7

The answers to 1a,b,2a,b,3a,b,4a,b may be found in the back of this SW.

1. Convert the following powers of ten into whole numbers.

   a. $4.5 \times 10^2 =$

   b. $4.5 \times 10^{-2} =$

   c. $2.93 \times 10^{-3} =$

   d. $1.76 \times 10^4 =$

2. Convert the following decimals into Scientific Notation.

   a. 420,000 =

   b. 0.002931 =

   c. 601,000 =

   d. 0.3790 =

3. Multiply the following powers of ten. Write the answer in Scientific Notation.

   a. $[4.2 \times 10^5]\ [5.4 \times 10^3] =$

   b. $[5.0 \times 10^{-3}]\ [3.0 \times 10^{-4}] =$

   c. $[2.5 \times 10^5]\ [2.5 \times 10^{-2}] =$

   d. $[2.93 \times 10^{-6}]\ [1.0 \times 10^2] =$

4. Divide the following powers of ten, write the answer in Scientific Notation.

a. $\frac{156 \times 10^6}{12 \times 10^3} =$

b. $\frac{273 \times 10^{-5}}{3.0 \times 10^{-3}} =$

c. $\frac{0.27 \times 10^{10}}{90.0 \times 10^{-4}} =$

d. $\frac{2.46 \times 10^{-3}}{6.0 \times 10^{7}} =$

Metric System

The metric system is based on decimals. Changing from one unit to another requires only the moving of the decimal point or multiplying by a power of ten.

The table below shows the meter, which is the standard unit of length, and the parts of a meter that we will be concerned with in Optometry. The standard abbreviations are in brackets and the number of each unit in one meter, written in powers of ten, to the right.

meter	(m)	10^0
centimeter	(cm)	10^2
millimeter	(mm)	10^3
micron	(u)	10^6
nanometer	(nm)	10^9

N.B. 1 millicron (mu) = 1 nanometer (nm) and may be used interchangeably

To convert from one metric unit to another the powers of ten method is recommended. Let us say that you are required to convert 685 mm to cm. Take the number of each unit, in powers of ten, in one meter. That would be 10^3 for mm and 10^2 for cm. Then find the difference between the two powers of ten and this will be your conversion factor, i.e., $10^{\pm 1}$. You then think to yourself, is what I want a smaller unit than what I had? If so, then I'll need to multiply by 10^{+1} so that I get more of a smaller unit. On the other hand if what I want is a larger unit I'll have to multiply by 10^{-1} so that I have less of a larger unit. In the case of 685 mm to cm I'm going to a larger unit so I multiply by 10^{-1} to give me

685 mm = 685×10^{-1}cm

or 68.5 cm

Further examples would be

1. 670 mm to microns (u)

$\underbrace{10^3 \qquad\qquad 10^6}_{10^{+3}}$ plus because we need more microns

$= 670 \times 10^{+3} = 670{,}000$ u $= 6.7 \times 10^{+5}$u

2. $$\underbrace{\underset{10^{2}}{1373\ \text{cm}} \longrightarrow \underset{10^{0}}{\text{m}}}_{}$$

10^{-2} minus because we need less meters

$1373 \times 10^{-2} = 13.73\text{m} = 1.373 \times 10^{1}\text{m}$

3. $$\underbrace{\underset{10^{9}}{2359\text{mu}} \longrightarrow \underset{10^{2}}{\text{cm}}}_{}$$

10^{-7} minus because we need less cm

$2359 \times 10^{-7} = 0.0002359\text{cm} = 2.359 \times 10^{-4}\text{cm}$

EXERCISE 8

Convert the metric unit of length on the left to the unit of length on the right and write your answer in Scientific Notation.

Answer to questions 1-4 may be found in the back of the SW.

1. 42m = ________cm

2. 500mm = ________m

3. 82u = ________mm

4. 357u = ________nm

5 122cm = ________mm

6. 423mm = ________cm

7. 8852u = ________m

8. 50cm = ________m

CHARACTERISTICS OF LIGHT

The bald fact is that no one really knows what light actually is. In this section we will be trying to give you some working definitions of light and also some light theories to try and give you some understanding of light.

Defining Light

There are two definitions of light that we should be familiar with - a technical and a clinical definition. The clinical definition is the one we will use in this course.

Technical: a form of radiant energy which stimulates the receptor cells of our eyes so as to cause the sensation of vision.

Clinical: light is that which we see by.

Thus in this course we don't regard electromagnetic radiation outside of the visible spectrum as light because we cannot see by it.

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Theories of Light Propagation

Space in this SW does not permit a discussion of all theories of light, but some of them are discussed briefly in order to give you an idea of their impact on the development of current light theories. Read through these theories and then they will be summarized to show you which theory to use in different areas of optics.

The ancient Greeks believed that light was generated from streams of particles ejected from the eyes, then reflected back into the eye by objects they struck. This theory didn't last long as it didn't explain why people couldn't see so well by night as by day.

During the 17th century, Sir Isaac Newton announced his CORPUSCULAR THEORY of light. He assumed that light was a flight of material particles originating at the light source. He believed that light rays moved at tremendous speed in a state of near vibration and could pass through space, air and transparent objects.

Newton's theory concurred with the idea that light moves in a straight line, but it did not explain other characteristics of light. He accidentally discovered a form of light interference of which he did not understand the significance but which are now called Newton's Rings.

During Newton's era, Christian Huygens announced his concept of light, now known as Huygens' principle, which helps to explain some of the phenomena of optics. Huygens attempted to show that the laws of reflection and refraction (explained later) could be explained by his theory of WAVE MOTION of light.

Although Huygens' wave-motion theory of light appeared to be the logical explanation for some phases of light behavior, it was not accepted for many years. Huygens could explain the passage of waves through water, but he did not know how light waves came from the sun or passed through space. He then proposed that the waves passed through a medium which he called ETHER, the function of which was to serve light waves in the same manner as water serves the familiar waves of water. He assumed that ether occupied all space, even that part already occupied by matter.

About 50 years after Huygens announced his theory of wave motion of light, Thomas Young, Fresnel and others, supported the wave theory, and Newton's corpuscular theory was virtually abandoned. These three scientists accepted the ether theory and assumed that light was waves of energy transmitted by an elastic medium designated by Huygens as ether.

Three other scientists (Boltzmann, Hertz, and Maxwell) conducted experiments which proved that light and electricity are similar in radiation and speed. As a result of their experiments, they developed the ELECTROMAGNETIC THEORY. They produced alternating electric currents with short wavelengths which were undoubtedly of electromagnetic origin and had all the properties of light waves. This theory (sometimes called the Maxwell theory) held that energy was given off continuously by the radiating body.

Heat, radio waves, light waves, ultraviolet and infrared rays, X-rays and cosmic rays are all forms of radiant energy of different wavelengths and frequencies. Together all of these form the electromagnetic spectrum, illustrated in figure 3. The visible portion of the electromagnetic spectrum consists of wavelengths from 0.00038 to 0.00066 mm. The different wavelengths within this range correspond to different colors of light. Note the arrows which point to the wavelengths of the colors of the rainbow in the spectrum (vision and photography) are in millimicrons of wavelengths. Wavelengths in the electromagnetic spectrum (denoted on the extreme left of figure 3) are in microns. Note in illustration 3 that the wavelengths we call light are between 400 and 700 mu, Each spectral color has its own small range of wavelengths. If light around 660 mu, for example, reaches your eyes, you see red (sensation of red on the retina). Around 460 mu the wavelengths of light that reach your eyes are blue; so the red waves are therefore much longer than the blue waves.

When light with a wavelength of 300 mu reaches your eyes, you receive no sensation of color. Radiation of this wavelength is generally called ultra-violet light. U. V. rays (radiation) from the sun cause sunburn and sometimes blisters. CAUTION: All short-wave radiations can do some damage if you get too much of them. Note that the infrared light rays are between 1 micron and 100 microns in the electromagnetic spectrum. These rays are called HEAT rays. We cannot see infrared rays; but if we could see them, everything would look different.

For some years after the promulgation of the Maxwell theory of light, scientists thought the puzzle of light was definitely solved. In 1900, however, Max Planck rejected the electromagnetic theory. He did not hold the view that energy from a radiating body was given off continuously. His contention was that the radiation body contained a large number of tiny oscillators, possibly resulting from electrical actions of atoms in the body. His idea was that the energy given off by the body could be of a high frequency and have high energy value, with all possible frequencies represented. Planck argued that the higher the temperature of the radiating body the shorter the wavelength most energetic radiations would have.

To account for the manner in which radiation from a warm, black body is distributed among the different wavelengths, Planck found an equation to fit the experimental curves, which were based on light-waves of different length. He then came to the conclusion that the small particles of radiated energy were grains of energy like grains of sand. He therefore called these units quanta and named his theory the QUANTUM THEORY. He assumed that when quanta were set free, they moved from their source in waves.

A few years later, Albert Einstein agreed with Planck relative to his quantum theory, and stated that, when emitted, light quanta retained their original identity as packets of energy.

Through experimentation, R. A. Millikan later proved that the energy caused by motion (kinetic energy) of units of light (photons) behaved in the manner assumed by the quantum theory. In 1921 A. H. Comptom learned through experiments that electrons and photons have kinetic energy and momentum and that they behave like material bodies. This idea, therefore, was somewhat similar to the old corpuscular theory.

Knowledge gained later by scientists from the study of diffraction, interference, polarization and velocity (explained later) proved the corpuscular theory untenable. More recently, phenomena of light have been discovered which are not accounted for by the wave theory so many scientists now accept Maxwell's electromagnetic theory.

So basically we have three theories of light propagation:

1. The wave theory which says that light travels along waves.

2. The particle theory which say that light is composed of high speed particles emitted from a luminous body.

3. The electromagnetic wave theory, an extrapolation of the wave theory which regards light as a combination of electric and magnetic forces.

Usage of Light Theories

For the sake of simplicity and ease of understanding we will use the particle theory to explain emission and absorption of light. Emission is the giving off of light energy (by a light bulb, candle or other luminous body) and absorption is the taking in of light energy and converting it to another energy form, usually heat. A car sitting out in the sun reflects the characteristic color of the car and absorbs all the rest of the rays converting them to heat energy.

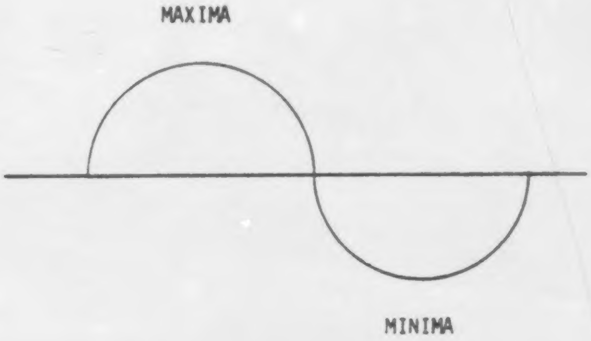
Much of this course will deal with the effects of lenses on light, which is transmission of light energy. The wave theory will be used to explain transmission of light through any medium; air, water, lenses or any other optical device, including the eye.

To illustrate the concept of the wave theory, secure one end of a rope to some object and hold the other end in one hand. Then stretch the rope fairly tight and shake it. The wave motion (pulse) passes along the rope from the end held to the end secured.

If you continue to shake the rope, you create a series of waves (a wave train). Note that parts of the rope (medium) vibrate successively; each bends back and forth but the medium does not. The disturbance travels but the medium does not. Only energy is carried along the rope.

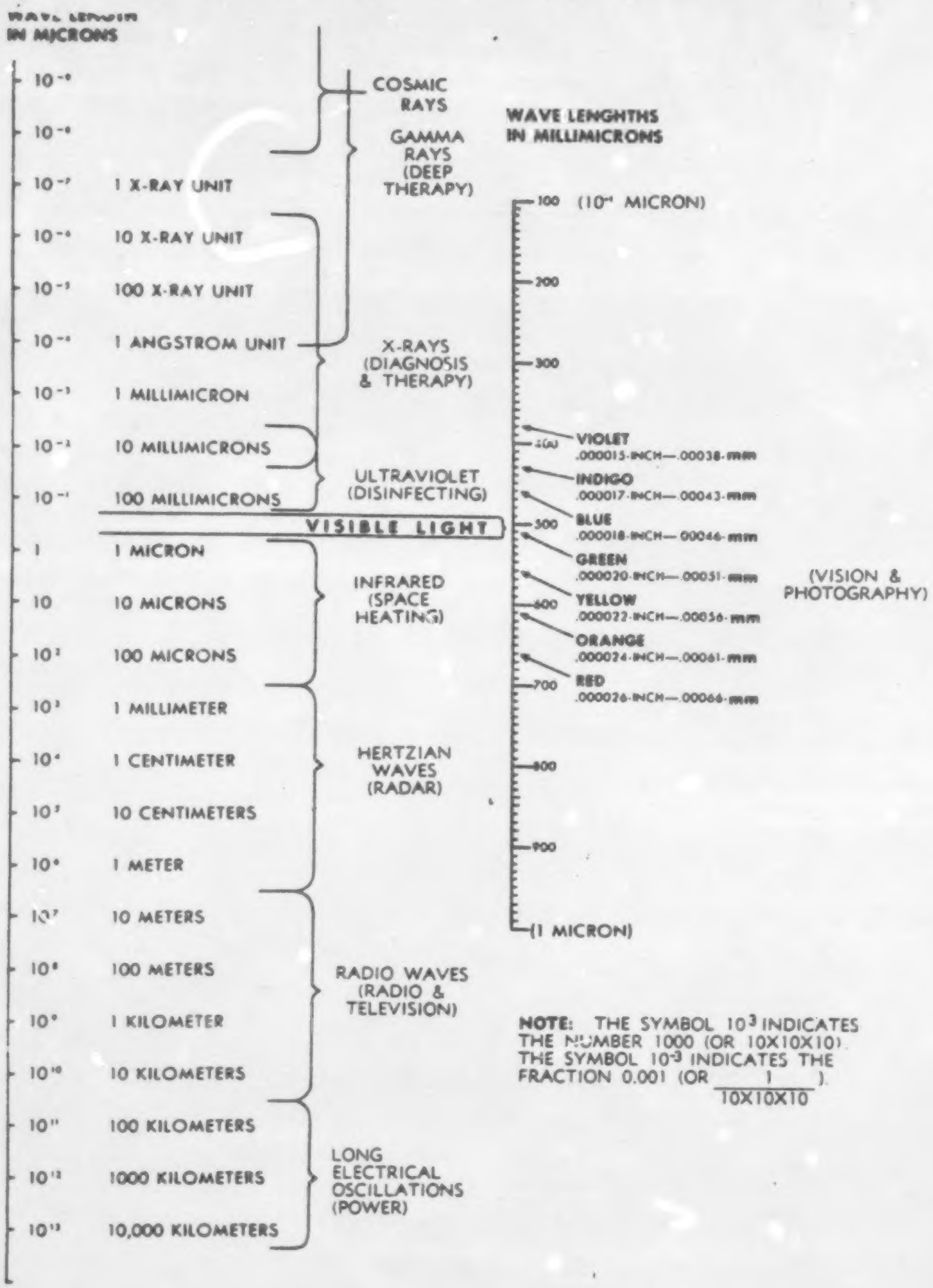
Imagine now that the light source is a vibrating ball from which a countless number of threads extend in all directions. As the ball vibrates, successive waves are transmitted along the threads. Light radiates from its source in a similar manner.

WAVELENGTH, AMPLITUDE, FREQUENCY AND VELOCITY OF LIGHT WAVES. Before getting into any definitions or explanations its always best to get the terminology straight. If you throw a rock into a pool of water, you will get waves. The CREST is the top of the wave and the TROUGH is the bottom. These may also be called MAXIMA (crests) and MINIMA (troughs), the terms may be used interchangeably. One complete waveform is called a CYCLE and is illustrated in figure 4 below.



One Complete Cycle

Figure 4


WAVE LENGTH
IN MICRONS
10^{-9}
10^{-8}
10^{-7}
1 X-RAY UNIT
10^{-6}
10 X-RAY UNIT
10^{-5}
100 X-RAY UNIT
10^{-4}
1 ANGSTROM UNIT
10^{-3}
1 MILLIMICRON
10^{-2}
10 MILLIMICRONS
10^{-1}
100 MILLIMICRONS
VISIBLE LIGHT
1
1 MICRON
10
10 MICRONS
10^{2}
100 MICRONS
10^{3}
1 MILLIMETER
10^{4}
1 CENTIMETER
10^{5}
10 CENTIMETERS
10^{6}
1 METER
10^{7}
10 METERS
10^{8}
100 METERS
10^{9}
1 KILOMETER
10^{10}
10 KILOMETERS
10^{11}
100 KILOMETERS
10^{12}
1000 KILOMETERS
10^{13}
10,000 KILOMETERS
COSMIC RAYS
GAMMA RAYS (DEEP THERAPY)
X-RAYS (DIAGNOSIS & THERAPY)
ULTRAVIOLET (DISINFECTING)
INFRARED (SPACE HEATING)
HERTZIAN WAVES (RADAR)
RADIO WAVES (RADIO & TELEVISION)
LONG ELECTRICAL OSCILLATIONS (POWER)
WAVE LENGTHS
IN MILLIMICRONS
100 (10^{-1} MICRON)
200
300
400
500
600
700
800
900
(1 MICRON)
VIOLET
.000015-INCH—.00038-mm
INDIGO
.000017-INCH—.00043-mm
BLUE
.000018-INCH—.00046-mm
GREEN
.000020-INCH—.00051-mm
YELLOW
.000022-INCH—.00056-mm
ORANGE
.000024-INCH—.00061-mm
RED
.000026-INCH—.00066-mm
(VISION & PHOTOGRAPHY)

NOTE: THE SYMBOL 10^3 INDICATES THE NUMBER 1000 (OR 10X10X10). THE SYMBOL 10^{-3} INDICATES THE FRACTION 0.001 (OR $\frac{1}{10X10X10}$).

Figure 3

If you remember the waves on water analogy, you shouldn't have any trouble with light waves.

A WAVELENGTH, (Lambda), is the distance between any point on a wave to the same point on a adjacent wave. Figure 5 below, shows different ways of measuring wavelenghth.

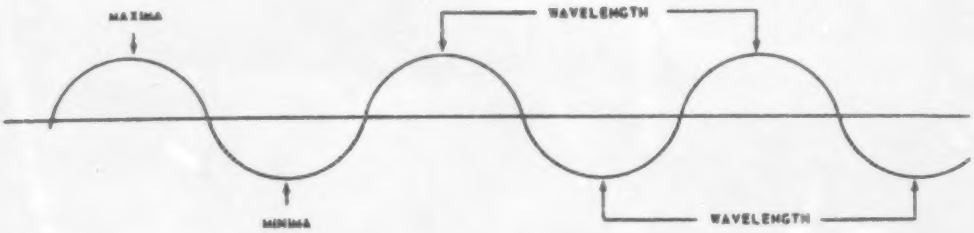


Figure 5

The use of modern and precise methods based on interference and diffraction has enabled scientists now, to measure light wavelengths with great accuracy.

Because sunlight includes the whole range of wavelengths between 400 mu and 700 mu, it is a mixture of all visible colors between red (700 mu) and violet (400 mu). When the sun is shining, put a prism on a table in a room with one window and cover the window with dark paper or cloth. Then cut a horizontal slit about an inch long and 1/16th of an inch wide in the paper to admit a small quantity of light. Hold the prism close to the paper to insure passage of sunlight onto one of the long faces of the prism. At the same time, hold a ground glass plate or a sheet of white paper on the other side of the prism, 6 to 8 inches away. When the sunlight passes through the prism, wavelengths of various colors refract at different angles toward the base of the prism and produce the spectrum of colors on the glass plate or piece of paper. This breaking down of white light into its component colors is called DISPERSION.

A pure spectral color is composed of light of one wavelength, or a very narrow band of wavelengths. When this light enters your eyes, it gives a sensation of color; but you cannot judge the wavelengths of light from color sensation. Most of the colors you see are not pure spectral colors, but mixtures of these colors. The sensations you get from these mixtures are therefore not always what you may expect. By mixing these three colors - red, blue, and green - in the correct intensities, you can produce many different colors and if you mix all three of them together you get white.

You must be sure not to confuse the mixing of paints and the mixing of lights. If you mix yellow and blue paints, for example, you get green because you combine the absorbing powers of the two paints. The blue paint reflects some of the spectral violet, a high percentage of the spectral blue, and some of the green. It absorbs all other colors. The yellow paint absorbs the violet and blue, reflecting all other colors in varying degrees. So the only color not totally absorbed by both paints is green.

Color vision will be covered more thoroughly in Block II.

Amplitude and Brightness Relationship

Amplitude, a, is the maximum displacement of the waveform. Figure 6, below, shows the amplitude of a waveform.

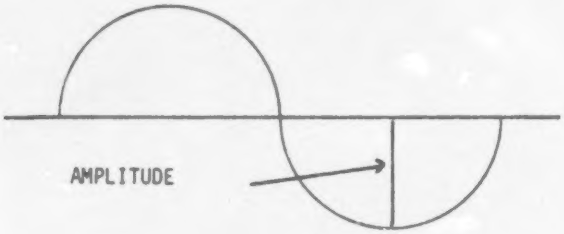


Figure 6

The greater the amplitude of a light wave, the brighter the light will appear to be. In other words, if two lights of the same color are side by side and one is brighter than the other, the brighter light is brighter because it is a greater amplitude than the dimmer (lower amplitude) light.

Frequency

Frequency is the number of waveforms (cycle) that pass a given reference point in a measured amount of time, usually one second.

If one were to put a stake in our pool of water as a reference point, and then count the number of crests passing that stake in a given unit of time, this would give us frequency. Let us say that 40 crests (each one representing a complete cycle) pass the stake in a 10 second time frame. We may write this:

$$\frac{40 \text{ cycles}}{10 \text{ seconds}} = 4 \text{ cycles/second}$$

Light frequencies are measured in much the same fashion, but bear in mind that frequency depends upon the wavelength and velocity of the wave.

Velocity of Light

Because light travels at such high velocity, it was years before anyone could measure its speed. Galileo tried to measure it by having two men in towers, on hills some distance apart, flash lights at each other. Each person flashed his light as soon as he saw the light signal of the other. Galileo reasoned that he could determine the speed of light by dividing the total distance the light traveled by the time required for transmission of signals. His experiment was not successful; he concluded that the speed of light was too great to be measured by this method. His final thought relative to the speed of light was that its transmission through space was perhaps instantaneous.

Olaus Roemer, a Danish astronomer, in 1675 calculated the speed of light by observing the irregularities in the times between successive eclipses of the innermost moon of Jupiter by that planet.

Roemer observed the position of Jupiter's moons revolving around the planet. The moons appeared on one side and then moved across in front of the planet and disappeared behind it. He could calculate accurately when one of the moons would be eclipsed by the planet. When he calculated six months ahead and then observed the actual eclipse, he learned that the moon eclipse occurred about 20 minutes later than he had calculated. He therefore concluded that the light had taken this amount of time to cross the diameter of the earth's orbit, which is about 186,000,000 miles. The difficulty was that Roemer did not correctly evaluate the speed of light even though he had the right idea. Subsequent measurements showed that the time difference was about 1000 seconds, which gave 186,000 miles per second as the speed of light.

The most accurate measurement of the speed of light were made after 1926 by A. A. Michelson, a distinguished American physicist, and his colleagues. Professor Michelson used an octagonal mirror apparatus that could be rotated at varying speeds. He measured the speed of light in air over the exact distance between Mt. Wilson and Mt. San Antonio, California. The light source (mirror) and telescope were located on Mt. Wilson, and the concave and plane mirrors were located on Mt. San Antonio, about 22 miles distance. Professor Michelson later on used an evacuated tube one mile long to measure the speed of light in a vacuum. The vacuum tube removed variations in air density and haze from the test, and the experiment showed that the speed of light in a vacuum was slightly higher than in air.

Modern physicists compute the speed of light with great accuracy but for all practical purposes the speed of light in air or a vacuum is considered to be 186,000 miles per second. In media that are optically more dense than air the speed of light is slower. All colors of light travel at the same speed in air or empty space, but in denser media, the speed of light varies for different colors which accounts for the dispersion of light through a prism.

It is this difference in the speed of light through air, glass and other substances that accounts for the bending of light rays. Without this characteristic of light a lens could not bend light rays to a focus, as you will learn later in this text.

EXERCISE 9

1. Define light as we will use it in this course.

2. Is ultraviolet considered to be light?

3. When we speak of transmission of light we will talk in terms of the _________ theory.

4. The visible portion of the electromagnetic spectrum extends from _______ mu to _________ mu.

5. A change in wavelength is perceived by the human eye as a change in _____________.

6. Brightness is directly related to _____________.

7. How fast does light travel in a vacuum?

8. Light (speeds up) (slows down) when it strikes a lens. (Cross out the incorrect answer)

REFLECTION

You know from experience that a mirror reflects light. A mirror will do predictable and dependable things to light. For example, you have looked at your own image in a flat mirror; from day to day you always look the same, or at least if you do look different, it's not the mirror's fault. The characteristic of the dependability of plane mirrors has given birth to the Laws of Reflection.

Laws of Reflection

Before actually stating the law, let us make sure that we have our terminology straight. The ray of light that strikes the mirror is called the INCIDENT RAY: the ray that bounces off the mirror is known as the REFLECTED RAY. The imaginary line perpendicular to the mirror at the point where the rays strikes is the NORMAL. The angle between the incident ray and the normal is the ANGLE OF INCIDENCE; the angle between the reflected ray and the normal is the ANGLE OF REFLECTION. (See figure 7.)

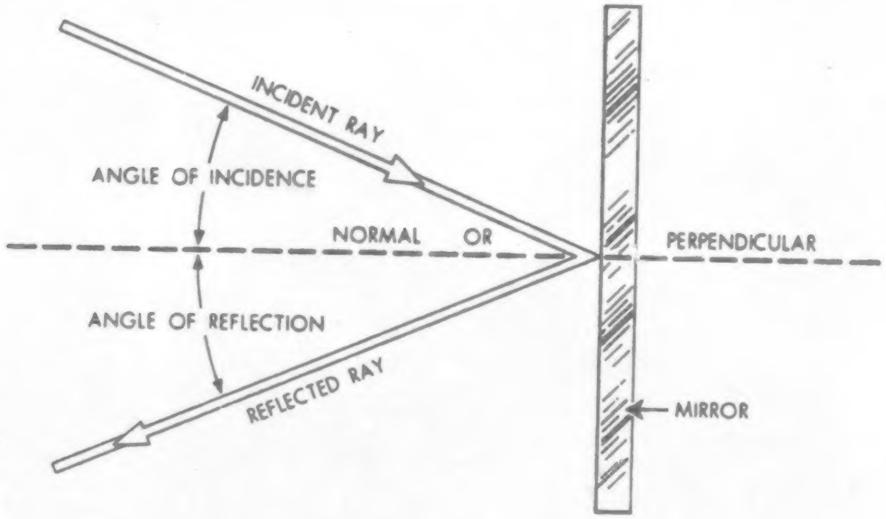


Figure 7

The laws of reflection are as follows:

1. THE ANGLE OF REFLECTION EQUALS THE ANGLE OF INCIDENCE.

2. THE INCIDENT AND REFLECTED RAY LIE ON OPPOSITE SIDES OF THE NORMAL.

3. THE INCIDENT RAY, THE NORMAL, AND THE REFLECTED RAY ALL LIE ALONG THE SAME PLANE.

By applying the law of reflection, you can see that in all cases of reflection, the angle of reflection can be plotted as long as the angle of incidence is known or vice - versa.

Regular and Diffuse Reflection

Regular reflection occurs when light strikes a smooth surface and is reflected in a concentrated manner. You can plot the direction in which any single ray of light will be reflected, by erecting a perpendicular or normal at the point of impact and by applying the law of reflection.

Diffuse reflection occurs when a beam of light strikes a rough surface such as a sheet of unglazed paper, the light is not reflected regularly but is scattered in all directions. This is an example of diffuse reflection light.

Spherical Mirrors

A curved mirror either increases or decreases the vergence of a light ray. Such mirrors are classified as either a convex mirror - curved outwards - or a concave mirror - curved inwards. A convex mirror causes parallel light rays to become divergent.

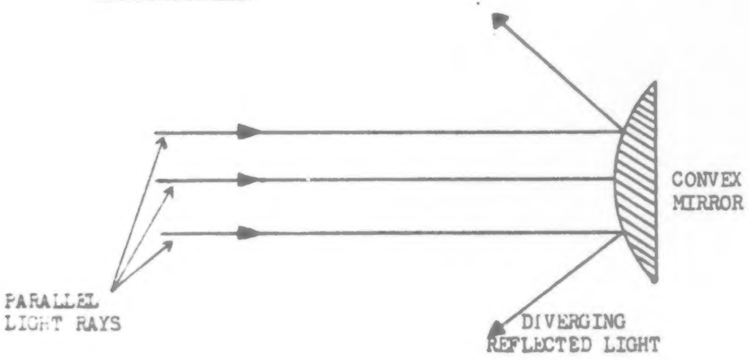


Figure 8

A concave mirror causes parallel rays of light to become convergent.

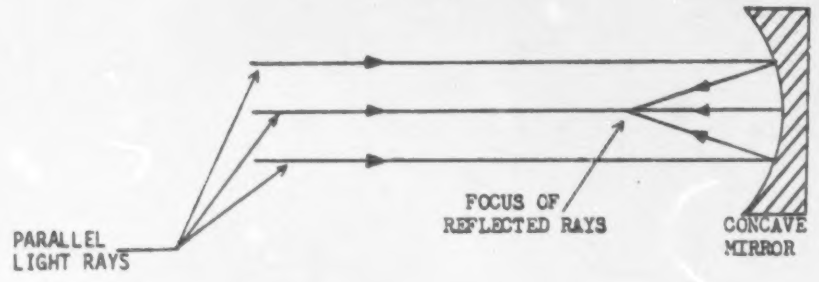


Figure 9

A light ray striking a mirror head on or perpendicular to the mirror is reflected back on itself.

When determining at what angle the light ray is reflected from a curved mirror we construct a normal at the point of incidence. Then we apply the law of reflection and the angle of reflection will equal the angle of incidence.

Images

An image is the optical counterpart of an object produced by a lens, mirror or an optical system (including prisms). Two types of images are produced - (1) real and (2) virtual.

A REAL IMAGE ACTUALLY EXISTS AND CAN BE THROWN UPON A SCREEN. It is produced by real foci (points of intersection of light rays). An image formed on a photographic plate is a good example of a real image, as is also true of an image formed on a motion picture screen.

A VIRTUAL IMAGE GETS ITS NAME FROM THE FACT THAT IT HAS NO REAL EXISTENCE. IT IS FORMED BY VIRTUAL (imaginary) FOCI AND CANNOT BE THROWN UPON A SCREEN. Your image in a mirror is a good example of a virtual image. Reflected rays of light which strike your eyes from the mirror to form your image in it. Your image in the mirror, in fact, appears to be on the other side, but this is only an optical illusion produced by the plane mirror.

An optical element produces an image by collecting a beam of light from an object and transforming it into a beam which CONVERGES TOWARD or DIVERGES FROM ANOTHER POINT. If the beam actually CONVERGES to a point, it produces a real image of the object; if the beam DIVERGES from a point, it produces a virtual image of the object.

You can ascertain whether an image is real by holding a piece of paper where the image is formed. If you can see the image on the paper, IT IS A REAL IMAGE, If you can see the image but cannot form it on paper, IT IS A VIRTUAL IMAGE. If the image is backwards, the optical term is REVERTED, and ERECT is the optical term for right side up. INVERTED means upside-down. When you desire to describe an image - as compared to its actual object - you can say that it is:

1. Real or virtual

2. Erect or inverted

3. Normal or reverted

4. Of the same size as the object, larger (magnified) or smaller (minified) than the object.

Tracing Light Rays to a Concave Mirror

Now we are going to apply all the facts that you have learned by tracing light rays to a concave mirror. First off, we must construct normals at points where light rays are going to strike the concave mirror. If we continue the curve of the mirror until we have a full circle, then any radius drawn from the center of the circle to the circumference will be a normal, or perpendicular to the surface.

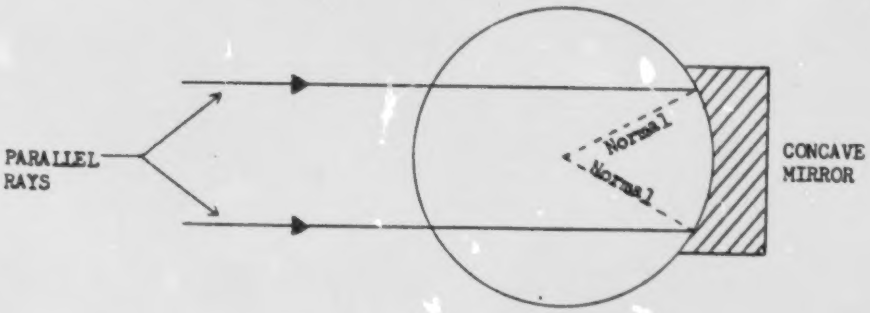

PARALLEL RAYS
Normal
Normal
CONCAVE MIRROR

Figure 10

Once the normals have been constructed at the points where the incident light rays will contact the mirror, the angle of the reflected ray can be determined as it equals the angle of the incident ray.

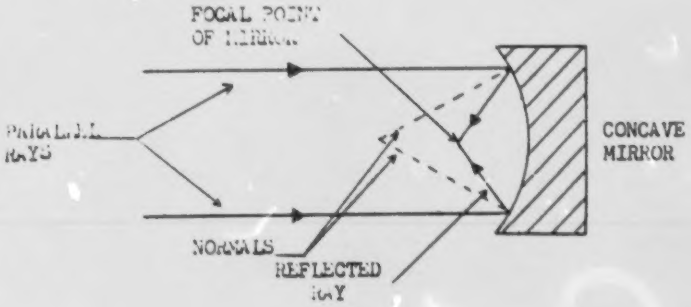

FOCAL POINT OF MIRROR
PARALLEL RAYS
CONCAVE MIRROR
NORMALS
REFLECTED RAY

Figure 11

The point where the reflected rays of PARALLEL incident light meet or cross is the focal point of the mirror. Therefore, a light source placed in the focal point of a concave mirror, will be reflected off the mirror as parallel light rays, which is the principle used in flashlights and vehicle headlights, etc.

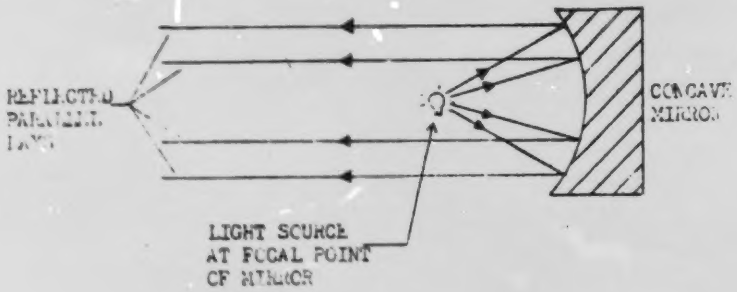

REFLECTED PARALLEL RAYS
CONCAVE MIRROR
LIGHT SOURCE AT FOCAL POINT OF MIRROR

Figure 12

The overall general rule for rays of light striking a concave mirror is as follows: When diverging rays of light strike a concave mirror, they become either convergent, parallel, or if the rays are more divergent than the mirror is convergent, the diverging rays are rendered less divergent.

When parallel light rays strike a concave mirror, the reflected rays become convergent.

Convergent rays striking a concave mirror produce more convergent rays than they originally were.

Tracing Light Rays to Convex Mirrors

The same principles used for a concave mirror can be used for a convex mirror. The normals are constructed in the same manner by drawing radii of curvature to the points where light strikes the mirror, then the angles of reflection will again equal the angles of incidence.

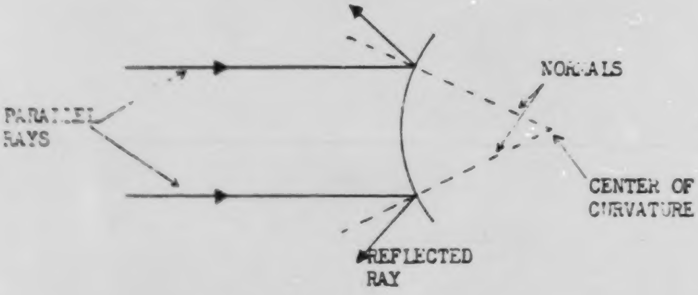

PARALLEL RAYS
NORMALS
CENTER OF CURVATURE
REFLECTED RAY

Figure 13

The general rule for convex mirrors - the opposite of concave mirrors will go as follows: Divergent rays of light striking a convex mirror will become more divergent. Convergent light rays will become more divergent (less convergent), and parallel light rays will become divergent.

SUMMARY

The law of reflection holds true for all surfaces - convex, concave, and plane. The amount of reflected light from curved surfaces depends upon the distance of the light source and the amount of curvature of the reflecting surface. THE PRINCIPAL FOCUS OF A CONCAVE MIRROR IS REAL. THE PRINCIPLE FOCUS OF A CONVEX MIRROR IS VIRTUAL (imaginary).

EXERCISE 10

Fill in the blanks.

1. The angle of reflection of a light ray may be determined by erecting a(n) ________ at the point where the ___________ ray strikes the mirror. Then the ___________ ____ __________________ will ___________ the angle of reflection.

2. A convex mirror will make light rays more ________________, or less ___________.

3. A concave mirror will make light rays more _____________, or less ____________.

Cross out the incorrect answer.

4. The picture thrown on a screen by a slide projector is a (real) (virtual) image.

5. A (real) (virtual) image is formed by an actual intersection of light rays.

6. A light source placed at the focal point of a concave mirror will produce (parallel) (divergent) (convergent) light rays after striking the mirror.

REFRACTION

Much of your time in the Optometry clinic will be spent ordering, dispensing and dealing with lenses. It will make your work far more interesting if you know how and why these lenses work.

Basically all optical devices work on the same principle - the bending or refraction of light waves. Let us start off by familiarizing ourselves with some of the rules that are observed throughout the field of optics.

Optical Sign Convention

You have already learned one of the rules of the optical sign convention, which we are going to use ... the rule that convergent light is considered positive (+), divergent light is considered negative (-) and parallel light is considered as zero (0) power. Another convention that we adopt is that we assume that light always travels from left to right (if it doesn't, we flip the optical system around so that it does). Any measurement made to the left of the lens is considered negative (-), and any measurement made to the right of the lens is considered positive (+). We use this method to classify lens types by where their focal point lies. Since a divergent lens causes light to have a virtual focus to the left of the lens it is considered (-) and called a MINUS LENS.

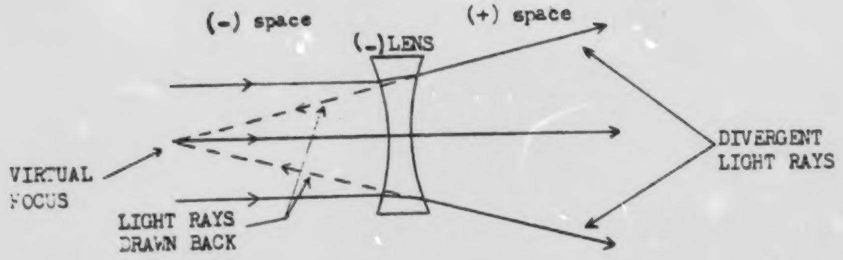


Figure 14

You might notice on the above diagram that the diverging or negative wavefront is in plus space. You must still consider the wavefront as negative as the rule of divergent light being negative overrides the fact that the waves are in plus space. The focus (virtual) is still in minus space.

On the other hand, a convergent lens causes light to have a real focus to the right of the lens so it is in POSITIVE (+) space and called a PLUS LENS.

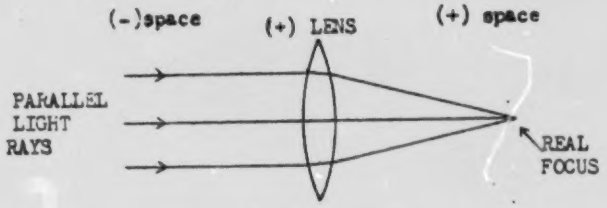


Figure 15

Definition of Refraction

We know now that all forms of light obey the same general laws. When light travels in a medium or substance of constant optical desity, it travels in waves in straight lines and at a constant speed. When light strikes a different medium from the one in which it is traveling, it is either reflected from or enters the medium. Upon entering a transparent medium, the speed of light is slowed down if the medium is MORE dense, or speeded up if the medium is LESS dense. Some substances of medium density have abnormal optical properties and for this reason, they may be designated as optically dense. If light strikes the medium at an angle, its course is bent, or REFRACTED as it enters the medium. Refer to figure 16 and use this diagram to relate to what is being said. As explained previously, without light, lenses, prisms and some other optical elements, we could not have optical instruments. After you learn the characteristics of light and the types and function of various optical elements, you will then experience less difficulty in understanding image formation - the prime purpose of optical instruments, including our eyes.

In figure 16, which shows what happens to rays of light as they pass through a sheet of glass. Both plane surfaces of this glass plate are parallel and air contacts both surfaces. Glass and air are transparent but the glass is optically denser than air, so light will travel approximately one-third slower in glass than in air.

When discussing the characteristics of light, however, we must use and explain these and other terms to the extent necessary for you to understand the discussion. Observe the dashed lines ($N + N'$) in the illustration. These are the normals erected for the INCIDENT and REFRACTED RAYS. They are the same as the normals we erected for mirrors - perpendicular to the surface at the point of contact of the incident ray.

When a light ray (wavefront) strikes the surface of the glass at right angles (parallel to the normal), it is not bent as it passes through the glass. This is true because each wavefront is slowed down when it strikes the glass surface, but it continues in the same direction it was going before striking the glass. When it squarely strikes the other surface of the glass, it passes straight through without deviation from its course. See the left side of figure 16.

If a wavefront strikes the first surface of the glass at an angle, as illustrated in part B of figure 16, one edge of the wavefront arrives at the surface an instant before the other edge; and the edge of the wavefront which arrives first is slowed down before the second edge as it enters the denser medium. Observe that the second edge continues to travel at the same speed, also, until it strikes the surface of the glass. This slowing down of one edge of the wavefront before the other edge causes the front to PIVOT TOWARD THE NORMAL. A good comparison with which, I'm sure, we are all familiar is the column of troops performing the movement - column half left. The inside files must slow down enough to allow time for the outer files to catch up. Think of the first edge of the wavefront to touch the glass as the inside file - it is slowed down by the greater density of the glass. The outer edge of the wavefront is still moving rapidly and so the inner edge catches up only by a change in angle of the complete wavefront.

The information just given relative to a wavefront which strikes a glass plate is applicable for any freely moving object when one side of the object is slowed down as it hits something, the other side continues to move at the same speed and direction until it also hits something. This action causes the object to pivot in the direction of the side which hits first and slows down. Pivoting or bending of light rays (wavefronts), as just explained, is called REFRACTION and the bent (pivoted) rays are called REFRACTED RAYS.

If the optical density of a new medium (glass in this case) remains constant, the refracted rays continue to travel in a straight line, as shown in part B of figure 16, until the surface from which they emerge (glass - to - air surface) causes interference. At this point, an opposite effect occurs to the wave. As one edge of the front reaches the surface (glass - to - air), it leaves the surface and resumes original speed (186,000 miles per second, at which it entered the glass).

Speeding up of one edge of the front before the other edge speeds up, causes the front to pivot again but this time it pivots toward the edge of the front which has not yet reached the surface of the glass. Again, THIS BENDING OR PIVOTING OF THE WAVEFRONT IS CALLED REFRACTION.

If the glass plate has parallel surfaces, the emergent light ray (ray refracted out of the glass) emerges from the second surface at an angle equal to the angle formed by the incident ray as it entered the glass. If you draw a dashed line along the emergent light ray (figure 16), straight back to the apparent source of the ray, you will find that the emergent ray is parallel to the incident ray. If the optical density of a new medium entered by a light is constant, the light follows its course in a direct line, as illustrated in part B of illustration 16.

You can demonstrate refraction visually by placing the straight edge of a sheet paper at an angle under the edge of a glass plate held vertically. Observe that the straight edge of the sheet of paper appears to have a jog in it directly under the edge of the glass plate. The portion of the paper on the other side of the glass

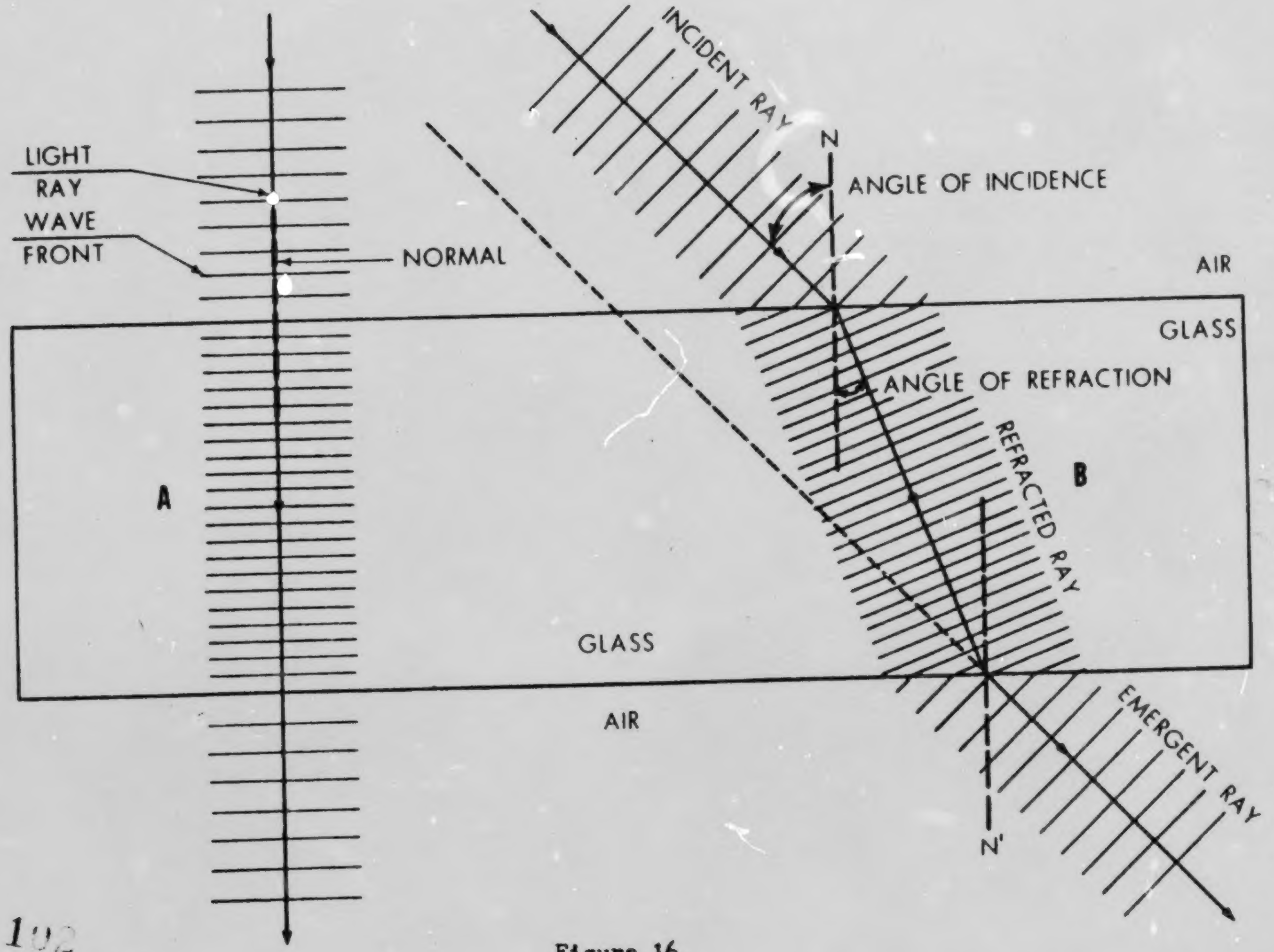

LIGHT RAY
WAVE FRONT
NORMAL
A
INCIDENT RAY
N
ANGLE OF INCIDENCE
AIR
GLASS
ANGLE OF REFRACTION
REFRACTED RAY
B
GLASS
AIR
EMERGENT RAY
N'

Figure 16

appears displaced as a result of refraction. If you move the sheet of paper in order to change the angle of its straight edge, the amount of refraction is increased or decreased.

Laws of Refraction

The laws of refraction are very important for an overall understanding in this course, because refraction is the principle that lenses are based upon. The laws of refraction are condensed into the following four statements:

1. WHEN LIGHT TRAVELS FROM A MEDIUM OF LESSER DENSITY TO A MEDIUM OF GREATER DENSITY, THE PATH OF THE LIGHT IS BENT TOWARD THE NORMAL.

2. WHEN LIGHT TRAVELS FROM A MEDIUM OF GREATER DENSITY TO A MEDIUM OF LESS DENSITY, THE PATH OF THE LIGHT IS BENT AWAY FROM THE NORMAL.

3. THE INCIDENT RAY, THE NORMAL, AND THE REFRACTED RAY ALL LIE IN THE SAME PLANE.

4. THE INCIDENT RAY LIES ON THE OPPOSITE SIDE OF THE NORMAL FROM THE REFRACTED RAY.

Study illustration 16, and then review carefully all the laws of refraction. Note the NORMAL, the ANGLE OF INCIDENCE and the ANGLE OF REFRACTION. This knowledge will be extremely valuable in later parts of the course.

The amount of refraction is dependent upon the angle at which light strikes a medium and the density of the new medium - the greater the angle of incidence and the greater the density of the new medicine, the greater the angle of refraction. If the faces of the medium are parallel, the bending of light at the two surfaces is always the same. As illustrated in part B of figure 16, the beam that leaves the optically denser medium is parallel to the incident beam because it is returning to the same medium from which it started.

Factors influencing Lens Power

There are many factors influencing lens power but the two primary variables are surface curvature and index of refraction.

INDEX OF REFRACTION. As you learned earlier the speed of light in a vacuum is 186,000 miles per second, but in other substances it travels slower because they are "optically denser." For example light travels through ordinary glass at only 120,000 m.p.s. The ratio between the speed of light in a vacuum and the speed of light in a medium is known as the INDEX OF REFRACTION of that medium and is conventionally denoted by the letter n. The formula then is:

$$\text{Index of Refraction } (n) = \frac{\text{velocity of light in vacuum}}{\text{velocity of light in medium}}$$

So in effect, index of refraction is just a way of relating the speed of light to optical density. The slower light travels, the more dense the medium is and the higher its index of refraction will be.

EXAMPLE:

$$\text{Index of Refraction (glass)} = \frac{186{,}000 \text{ mps}}{120{,}000 \text{ mps}} = 1.55$$

The following is a list of indices of refraction for some substances:

Vacuum	1.00000
Air	1.000293
Water	1.333
Boro-silicate crown glass	1.517
Thermosetting cement	1.529
Canada Balsam	1.530
Gelatin	1.530
Light Flint glass	1.588
Medium Flint glass	1.617
Dense Flint glass	1.649
Densest Flint glass	1.963
Diamond	2.416

The index of refraction of a transparent substance of high purity is a constant quantity of the physical properties of that substance. Therefore, determining the identity of a pure substance is very simple using a refractometer. A refractometer measures the index of refraction and, with a very pure substance, comparison with a table of known indices of refraction readily identifies the substance.

NOTE: You will be given the index of refraction if you need it for computations, so don't try and memorize them.

SURFACE CURVATURE. The angle of incidence of light rays is determined essentially by the degree of curvature of the lens surface. The problem is how does one indicate, quantitatively, the curvature of a surface. One way to measure surface curvature is by use of the radius from the center of curvature. A more curved surface will have a shorter radius of curvature than a less curved surface, as is exampled below in figure 17.

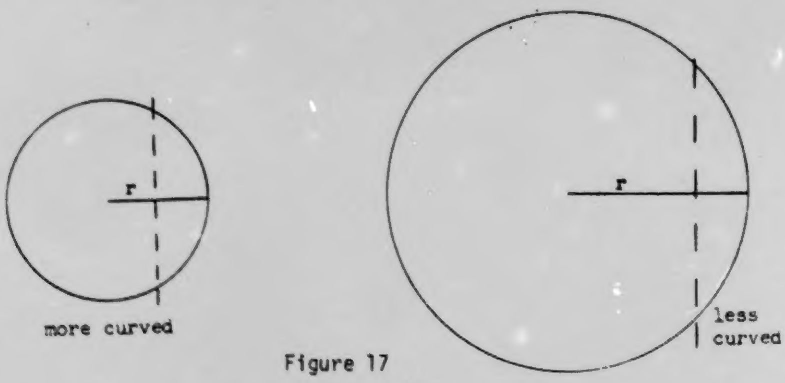


Figure 17

NOTE: Radius of curvature is indicated by the lower case letter r.

To determine whether r is plus or minus is done quite simply by observing whether or not the center of curvature is in plus (+) or minus (-) space. In figure 18 below the first surface has a plus (+) radius of curvature and the second surface has a negative (-) radius of curvature.

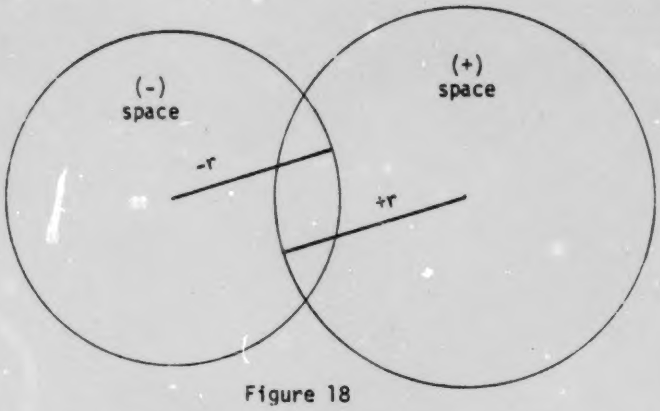


Figure 18

Later in this text when computing surface or total lens power with index of refraction and radii of curvature, make sure you remember to indicate whether r is plus or minus, as this will drastically affect the accuracy of your calculations.

SNELL'S LAW. From his observation, Willebrord Snell, a mathematician and astronomer at the University of Heyden, determined the following relationship called Snell's Law.

$$\frac{\text{Sin } i}{\text{Sin } r} = \frac{n2}{n_1}$$

Where i equals the angle of incidence, r equals the angle of refraction, n, is the index of refraction of the medium the light is traveling in, and n_2 is the index of refraction of the medium the light is about to enter.

It is therefore possible to determine the amount, or angle of refraction by knowing the angle of incidence (directly related to surface curvature and radius of curvature) and the indices of refraction of the two mediums on either side of the interchage.

Snell's Law also effectively proves the LAW OF REVERSIBILITY which states that, if the path of a light ray is reversed, it will retrace its path exactly, no matter how many prisms, mirrors, or lenses there are in the original system.

It is possible to use Snell's Law to compute the power of a lens but this computation is unnecessarily difficult; much simpler formulae exist and we will describe these later on in this text.

EXERCISE 11

Circle the Correct Answer

1. The optical sign convention states that all measurements made to the left of a lens are (plus) (minus) and measurements made to the right of a lens are (plus)(minus).

2. Convergent light always has (+)(-)(0) dioptric power.

3. When light strikes a medium of different optical density at an angle it will be (reflected)(refracted)(passed straight through).

4. When light travels from a medium of greater density to a medium of lesser density it will be bent (toward)(away)from) the normal.

COMPLETE THE STATEMENTS

5. The two primary factors influencing lens power are ______________________________

and ________________________.

6. A measure of a medium's optical density is its ________________ ____ _____________.

7. The curvature of a lens surface is measured in terms of its _____________ ______

_____________________________.

8. If the path of a light ray is reversed it will retrace its path exactly. This is

called the _____________ ________ ______________________________.

Vergence of Light Rays

During the latter part of the 18th century, scientists recognized that radiations from hot bodies consisted of electromagnetic waves (not mechanical) of the same fundamental nature as light waves. Luminous light sources such as the sun or the glowing filament of an electric light bulb act as oscillators in radiating energy in the form of light waves, and these waves spread out in all directions from their sources. The sun pours out radiant energy from its surface at the rate of 70,000 horsepower for every square yard of its surface.

Because light travels outward in all directions from its source, the waves take the form of growing spheres, the luminous point of which is the center.

Single rays of light do not exist but the term light ray is used throughout this SW for the sake of clarity and convenience in showing the direction of travel of the wavefront. Light is indicated by one or more representative light rays in lines with arrowheads to indicate the direction of travel.

Refer now to figure 19 and observe that light is diverging in all directions from the light bulb. Study the figure which shows lines with arrowheads to indicate that the direction of travel of the light is along the radii of the sphere of light and at right angles to the fronts of the waves. The light which travels along each of these radii is designated as a light ray.

A wavefront which radiates from a light source is curved when it is near the source and the radii of the waves diverge or spread as these waves move outward. However the wavefront becomes less curved and eventually almost straight. After traveling a distance of 2,000 yards from their light sources, wavefronts are considered to be parallel to each other. A parallel wavefront is neither converging nor diverging and thus is said to have zero (0) wave power.

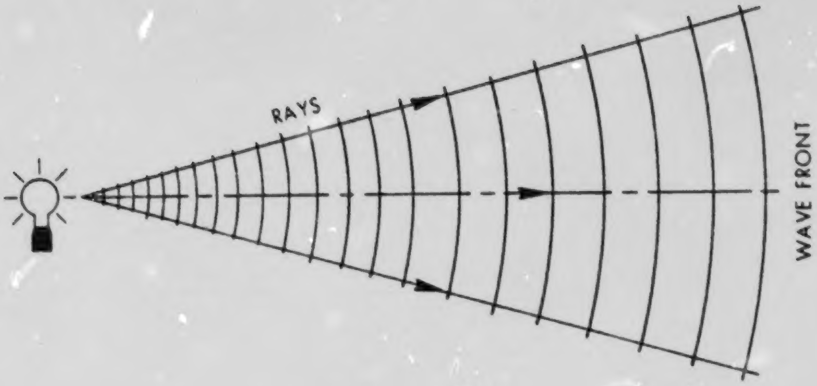


Figure 19

Divergent light is spreading out from a source or focus and is said to have negative (-) wave power. Divergent light is easily found in nature but it may also be produced by a minus lens. Minus lenses are overall concave, or thinner in the middle than at the edges.

Convergence of light rays occurs only after the light has passed through some type of optical system. Convergence is characterized by the light rays coming to a focus after passing through an optical system. Convergent or plus (+) lenses produce convergent or plus light. Convex lenses are overall convex or fatter in the middle than at the edges.

We may apply the laws of refraction to the convergent and divergent lenses to prove this. A plus lens is pictured in figure 20. Remember that we find the center of the circle, of which the lens is a part, and draw radii, to construct the normals.

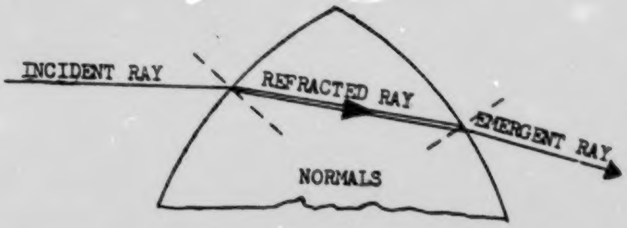


Figure 20

Of course we may do the same thing for minus lenses as shown below.

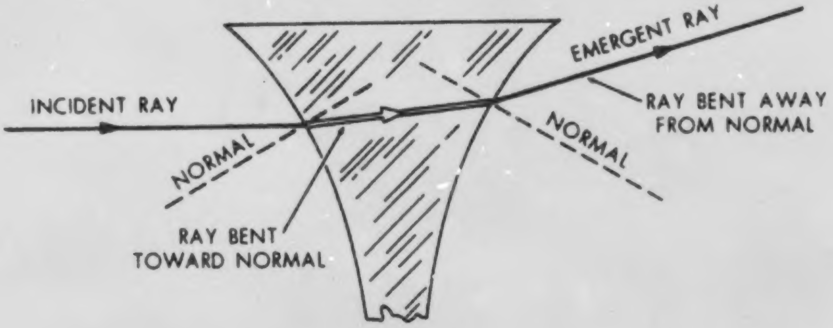

INCIDENT RAY
EMERGENT RAY
RAY BENT AWAY FROM NORMAL
NORMAL
NORMAL
RAY BENT TOWARD NORMAL

Figure 21

We have one more optical device that warrants introduction at this time and that is the prism. A prism has two surfaces that are not parallel, an apex, and a base. If we apply the laws of refraction to a prism (figure 22) we find that light is deviated toward the base of the prism. The orientation of a prism is always given in terms of the base i.e. base up, down, in or out.

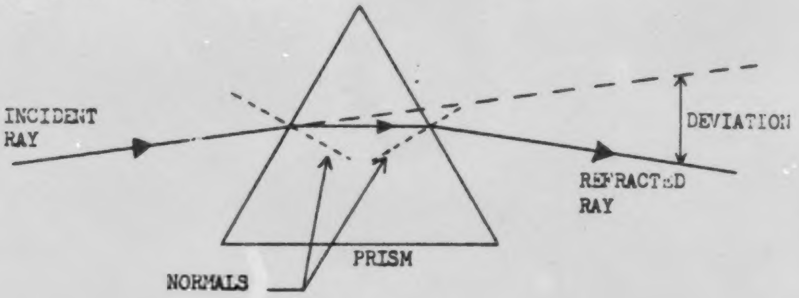
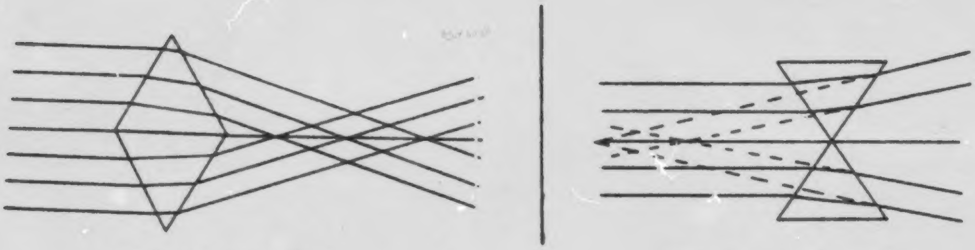

INCIDENT RAY
DEVIATION
REFRACTED RAY
PRISM
NORMALS

Figure 22

When we speak of refraction through a prism we usually call it DEVIATION, so that we may distinguish it from refraction through a lens.

It is possible to picture a plus or minus lens as two prisms and, accepting that lenses have rounded curves, this comparison is valid. Later on in this block we will cover the prismatic qualities of ophthalmic lenses in greater detail, but for now just compare the elements pictured in figure 23 with plus and minus lenses.



MULTIPLE REAL FOCI

MULTIPLE VIRTUAL FOCI

Figure 23

Next we will be exploring the mathematics of optical systems but you must remember that; a divergent ray or wavefront is considered as having negative (-) power, a convergent ray or wavefront is considered as having positive (+) power, a parallel ray or wavefront has zero (0) power, prisms always deviate light toward the base, and any lens may be throught of as two prisms base to base (a plus lens) or apex to apex (a minus lens) that have had their edges rounded off.

EXERCISE 12

Circle the correct answer.

1. Divergent light has (+)(-)(0) wavepower, while convergent light has (+)(-)(0) wavepower.

2. After 2,000 yards from a source, light is considered to be (convergent)(divergent)(parallel) and have (+)(-)(0) wavepower.

3. Concave lenses may also be called (+)(-)(0) lenses.

4. Convex lenses may also be called (+)(-)(0) lenses.

5. A plus lens is (fatter)(thinner) in the middle than it is at the edges, whereas a minus lens is (fatter)(thinner) in the middle than it is at the edges.

6. Light is always deviated toward the (apex)(base) of a prism.

7. A plus lens may be thought of as two prisms (apex to apex) (base to base) and a minus lens may be thought of as two prisms (apex to apex) (base to base).

DIOPTERS

The vergence of early optical systems was usually a matter of chance. Now, the power or strength of optical systems is measured with great accuracy, in terms of DIOPTERS.

A DIOPTER is a unit of measurement of lens or wave power, or it can also be thought of as the unit of measure of the refractive power of a lens or lens system.

A DIOPTER IS EQUAL TO THE RECIPROCAL OF THE FOCAL LENGTH IN METERS. The focal length of a lens is determined by putting parallel light into it and measuring how far away the light focuses. The focal length of a plus lens is real and formed by an actual intersection of light rays as in figure 24 below.

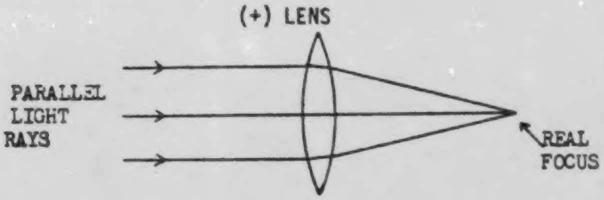

(+) LENS
PARALLEL LIGHT RAYS
REAL FOCUS

Figure 24

On the other hand, a minus lens diverges light and in reality these light rays will never cross or focus. But we may still find the focus by drawing back geometric extensions of the rays to form a virtual (imaginary) focus as in figure 25.

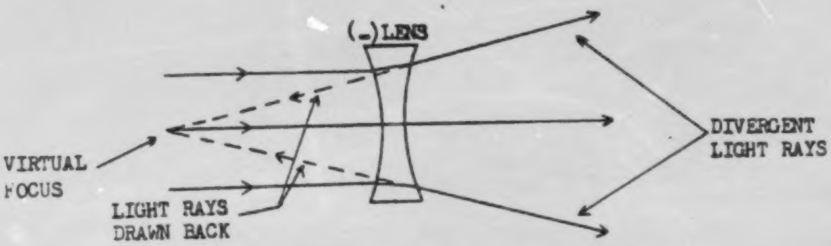

(-) LENS
VIRTUAL FOCUS
LIGHT RAYS DRAWN BACK
DIVERGENT LIGHT RAYS

Figure 25

We said that diopters of lens power are equal to the reciprocal of the focal length. We may write this in the form

$$D = \frac{1}{f(m)}$$

When D equals lens diopters, and f is the focal length. Thus a system with a focal length of 1 meter will have a power of 1 Diopter, as determined by substituting into the formula

$$D = \frac{1}{1m} = 1.000$$

A system with a focal length of 2 meters will have a power of:

$$D = \frac{1}{2m} = 0.50D$$

and a system with a focal length of 0.50 meters will have a power of:

$$D = \frac{1}{0.50m} = 2.00D$$

Our only problem then is to make sure that the focal length is entered in meters. As not all focal lengths are measured in meters, we may modify the basic formula by including an automatic conversion factor for different focal length units, as follows:

$$D = \frac{1}{f(m)} \qquad D = \frac{1000}{f(mm)}$$

$$D = \frac{100}{f(cm)} \qquad D = \frac{40}{f(in)}$$

So if you have a focal length in cm just plug it in to D = 100/f(cm) and the 100 will convert the cm to meters; so essentially we haven't changed anything.

Examples: 1. A focal length of 10cm

$$D = \frac{100}{f(cm)} = \frac{100}{10cm} = 10.00D$$

2. A focal length of 250mm

$$D = \frac{1000}{f(mm)} = \frac{1000}{250} = 4.00D$$

3. A focal length of 16 inches

$$D = \frac{40}{f(in)} = \frac{40}{16} = 2.50D$$

The same dioptric power formula may also be used to determine focal lengths if you know the lens diopters. We may rearrange the formula to isolate f in the following manner:

$$D = \frac{1}{f(m)}$$

multiply both sides by f(m)

$$f(m) \times D = \frac{1}{\cancel{f(m)}} \times \cancel{f(m)}$$

giving us

$$f(m) \times D = 1$$

then divide both sides by D

$$\frac{f(m) \times \cancel{D}}{\cancel{D}} = \frac{1}{D}$$

leaving us

$$f(m) = \frac{1}{D}$$

Thus if you have a lens of 5.00D it has a focal length of:

$$f(m) = \frac{1}{5} = 0.20\text{m}$$

If we wish to have our focal lengths in cm, mm, or inches we may use the same basic formula with an automatic conversion factor in the same way we did for diopters.

$$f(\text{cm}) = \frac{100}{D} \qquad f(\text{mm}) = \frac{1000}{D} \qquad f(\text{in}) = \frac{40}{D}$$

Examples: 1. A 3.00D lens will have a focal length, in cm, of

$$f(\text{cm}) = \frac{100}{D} = \frac{100}{3.0} = 33.33\text{cm}$$

2. A 10.00D lens will have a focal length, in inches, of

$$f(\text{in}) = \frac{40}{D} = \frac{40}{10.00} = 4.00 \text{ inches}$$

3. A 2.50D lens will have a focal length, in mm, of

$$f(\text{mm}) = \frac{1000}{D} = \frac{1000}{2.50} = 400\text{mm}$$

So to boil both of these formulae down, we can say that if you have a focal length, measured in some given unit (mm, cm, inches, etc) then just divide that quantity into the number of those units that exist in one meter (40 for f in inches, 100 for f in cm, 1000 for f in mm etc). If you have a focal length in cm then divide that number of cm into 100, or inches divide into 40. Conversely, if you have diopters and you need focal lengths in a certain unit, then divide that quantity of diopters into the number of desired units that exist in one meter. For example, if you need the focal length in mm then divide your diopters into 1000, or inches divide into 40.

If we step back and look at what the formula means we find that the larger the focal length the smaller the dioptric power; and the smaller the focal length the larger the dioptric power. In other words we are placing a number (D or f) in the denominator (bottom) of a fraction and the larger that denominator is the smaller the value of the fraction. If we were to place 4 and 64 as denominators in the same fraction ($D = 1/f$ or $f = 1/D$), which fraction will have the greater value? 1/4 is larger than 1/64 even though the numerical value of the denominator is smaller. The greater the dioptric power then the greater will be the angle of refraction which will produce a shorter focal length. Equally the longer the focal length then the less the light has been bent which means lower dioptric power. Observe the angles of refraction, focal lengths and lens powers in figure 26.

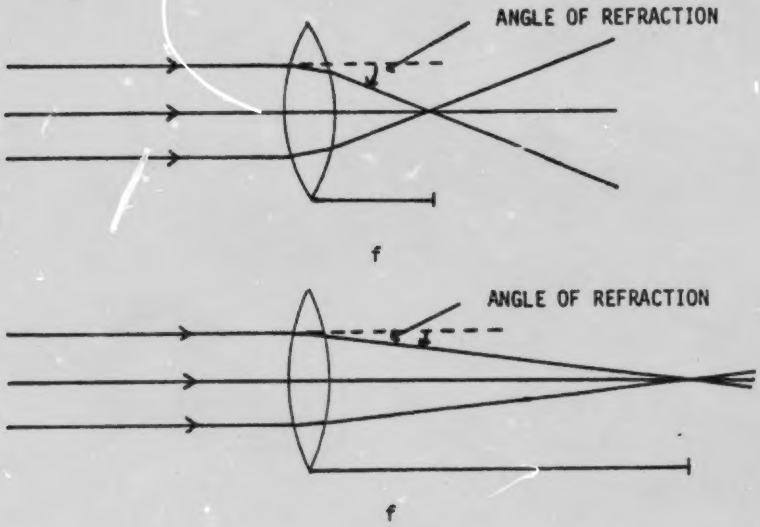


Figure 26

The power of an opthalmic lens is always given in diopters, but in many instances it is useful to know the focal lengths of these lenses. Make sure you can convert freely between focal lengths and diopters before continuing on.

EXERCISE 13

Convert the following focal lengths to diopters, taking your answer to two decimal places.

Answers to questions 1-5 may be found in the back of the SW.

1. 200 mm =
2. 25 cm =
3 80 in =
4. 0.20 m =
5. 16 in =
6. 50 mm =
7. 33 cm =

8. 0.75 m =

9. 100 cm =

10. 5 m =

Convert the following diopters to focal lengths taking your answer to two decimal places.

11. 2.25 D - __________cm

12. 0.50 D = __________in

13. 2.50 D = __________mm

14. 3.33 D = __________m

15. 10.00 D = __________cm

16. 5.00 D = __________in

17. 0.25 D = __________mm

18. 1.00 D = __________m

19. 50.00 D = __________cm

20. 20.00 D = __________in

The Single Surface Power Formula

Using focal lengths is not the only way to determine the dioptric power of a lens. We already know that refraction only takes places at a lens surface therefore if we could figure the power of each surface and algebraically add them together we would have the total power of that lens.

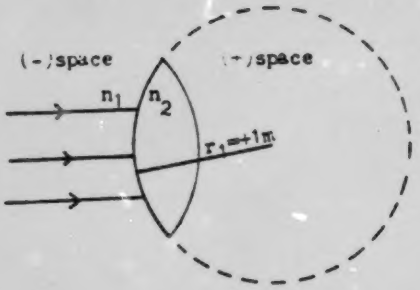
You recall that Snell's Law determined that the angle of incidence and index of refraction could be used to calculate the angle of refraction. From this Law a relationship, incorporating angle of incidence and index of refraction, was derived to figure the power of a lens, in diopters. This relationship is called the Single Surface Power Formula and is written in the form:

$$D = \frac{n_2 - n_1}{r(m)}$$

Where D equals the power of the lens surface in diopters, n_2 is the index of refraction of the second medium, n_1 is the index of refraction of the first medium, and r is the radius of curvature of the surface IN METERS. As we said, this will give the dioptric power of a single lens surface and applying this formula to both surfaces of a lens will yield the total power of the lens by algebraically adding the powers of both surfaces.

EXAMPLE:

1. What is the power of the first surface of a biconvex lens which has an index of refraction of 1.50 and a radius of curvatune of 1 meter?



$n_1 = 1.00$ (air = 1.00)

$n_2 = 1.50$

$r = +1m$

$$F = \frac{n_2 - n_1}{r(m)}$$

$$= \frac{1.50 - 1.00}{+1} = \frac{0.50}{+1}$$

$$= +0.50\ D$$

Figure 27

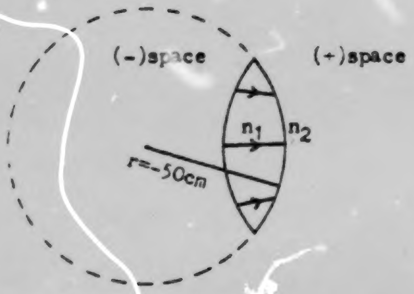
NOTE: That r is plus (+) because the center of curvature of the lens' surface is in positive space. Also, note that the index of refraction of air is 1.000, even though light does travel slightly slower in air than in a vacuum.

2. What is the power of the second surface of a biconvex lens which has an index of refraction of 1.50 and a radius of curvature of 50 cm?

$n_1 = 1.50$

$n_2 = 1.00$ (air)

$r = -50cm = -\ 0.50$ meters



$$D = \frac{n_2 - n_1}{r(m)}$$

$$= \frac{1.00 - 1.50}{-0.50\ m} = \frac{-0.50}{-0.50}$$

$$= +\ 1.00\ D.$$

Figure 28

NOTE: In the second example n_1 is now the lens, light was traveling from the lens to the the air (in the first example, light was going from the air into the lens). Also note that the radius of curvature for the second surface is minus (-) because its center of curvature is in minus space.

If both of these surfaces made up one lens, then the total power of the lens would be equal to:

$D_1 + D_2 = D_{Total}$

or

$+0.50 + (+1.00) = +1.50D.$

Notice that D_2 was twice the power of D_1 and the only difference between the two surfaces was the radii of curvature. The First r was 1 meter and the second was -0.50 meters or half or r_1 meaning that r_2 had twice the curvature. This should show you that surface curvature does affect the power of a lens. The formula mentioned above is easier to use than Snell's Law but in the next section we will consider an even easier formula for computing total lens power.

THE TOTAL LENS POWER FORMULA FOR THIN LENSES IN AIR. All that this formula consists of is two single surface power formulae added together and 1.00 substituted for n_1 in the first surface formula, and n_2 in the second surface formula, since 1.00 is the index of refraction of air. Algebraically it looks like this:

Where $D_{Total} = D_1 + D_2$

$$D_1 = \frac{n_2 - n_1}{r(m)} \text{ and } D_2 = \frac{n_2 - n_1}{r(m)}$$

Therefore $D_{Total} = \dfrac{n_2 - n_1}{r(m)} + \dfrac{n_2 - n_1}{r(m)}$

Substituting 1.00 for air

$$D_{Total} = \frac{n_2 - 1.00}{r(m)} + \frac{1.00 - n_1}{r(m)}$$

This may then be simplified to give use the formula for thin lenses in air:

$$D_{Total} = (n-1) \left\{ \frac{1}{r_1(m)} - \frac{1}{r_2(m)} \right\}$$

Where D_{Total} equals the total surface power of the lens in diopters, n equals the index of refraction of the lens, r_1 equals the first surface radius of curvature IN METERS, r_2 equals the second surface radius of curvature IN METERS.

EXAMPLES

1. What is the power of a biconvex lens which has an index of refraction of 1.50 and radii of curvature of 0.25 meters and 20.0 centimeters respectively?

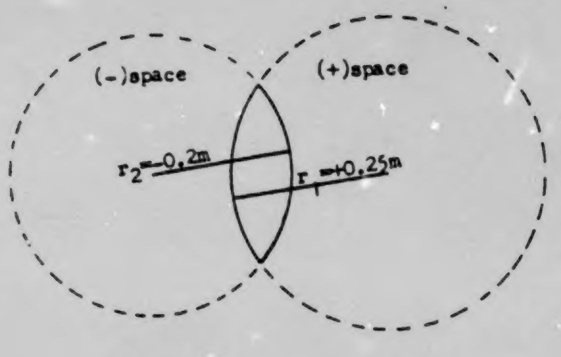


Figure 29

$n = 1.50$
$r_1 = 0.25 = +0.25\text{m}$
$r_2 = 20.0\text{cm} = -0.20\text{m}$

$$\begin{aligned} D_{\text{Total}} &= (n - 1)\left\{\frac{1}{r_1(m)} - \frac{1}{r_2(m)}\right\} \\ &= (1.50 - 1)\left(\frac{1}{+0.25} - \left(\frac{1}{-0.20}\right)\right) \\ &= (+0.50)\,(+4.00 - (-5.00)\,) \\ &= (+0.50)\,(+4.00 + 5.00) \\ &= (+0.50)\,(+9.00) \\ &= +4.50\text{D} \end{aligned}$$

Notice that r_2 has a negative radius of curvature and that when it was substituted into the formula it was bracketed off to prevent confusion with the two minus signs that ultimately became a plus. It's a good idea to use plenty of space and keep the problem in an organized fashion to prevent mathematical error.

2. What is the power of a biconcave lens which has an index of refraction of 1.50 and radii of curvature of 500 mm and 25 cm respectively?

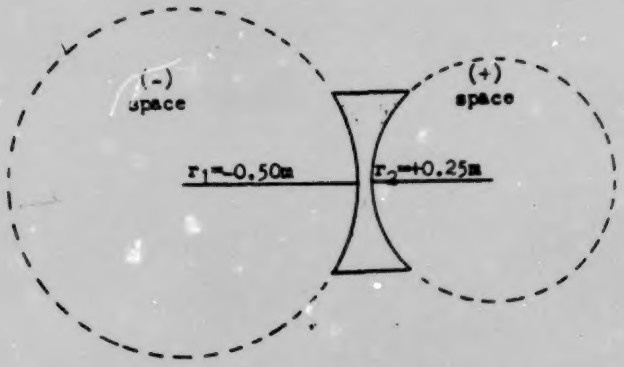


Figure 30

$n = 1.50$
$r_1 = 500\text{mm} = -\,0.50\text{m}$
$r_2 = 25\text{cm} = +\,0.25\text{m}$

$$D_{\text{Total}} = (n - 1)\left\{\frac{1}{r_1(\text{m})} - \frac{1}{r_2(\text{m})}\right\}$$

$$= (1.50 - 1)\left\{\frac{1}{-\,0.50} - \frac{1}{+\,0.25}\right\}$$

$$= (+0.50)\,(-2.00 - 4.00)$$

$$= (+0.50)(-6.00)$$

$$= -3.000$$

Notice that this time r_1 has a negative radius of curvature. Also note that r_1 and r_2 had to be converted to meters.

In both of the examples above you were told the shape of the lens. This should tell you what the sign of the answer will be, in other words a biconcave lens will always have minus (-) power and a biconvex lens will always have plus (+) power. If your calculations give you the wrong power then you know you have made a mistake somewhere.

EXERCISE 14

Compute the power of the following thin lenses in air.

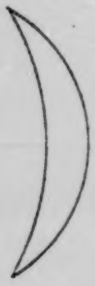
Perform your calculations to two decimal places.

Answers to questions 1 and 2 may be found in the back of this SW.

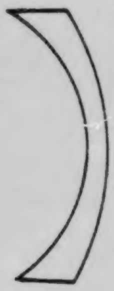
1. A biconvex lens with an index of refraction of 1.50 and radii of curvature of 2 meters and 20 cm, respectively.

2. A biconcave lens with an index of refraction of 1.70 and radii of curvature of 20 inches and 80 inches, respectively.

3. A concavo - convex lens with an index of refraction of 1.50 and radii of curvature of 50cm and 250mm respectively. A concavo-convex lens is drawn for you below.



4. A convexo-concave lens with an index of refraction of 1.50 and radii of curvature of 16 inches and 20 inches respectively. A convexo-concave lens is drawn for you below.



The Object-Image Wavepower Formula

This is a formula for figuring the power of a lens when you know the object and image distances. The basic concept behind this formula is that wavepower may be measured in terms of diopters. We know that a +5.00D lens produces, from parallel light, a focus 20 cm away. This means that the light must be bent such that its rate of convergence will produce a focus 20cm away. Thus the rate of convergence of a 5.00D lens will be twice as fast as a 2.50D lens. What we can do then, is label the rate of convergence or divergence of light with a dioptric value. If we have light diverging as if it had passed through a -2.00D lens we may label it as -2.00D light.

Let us consider the problem of determining the power of a lens that will focus an object 50 cm to the left, into an image 25 cm to the right. This is diagrammed in figure 31.

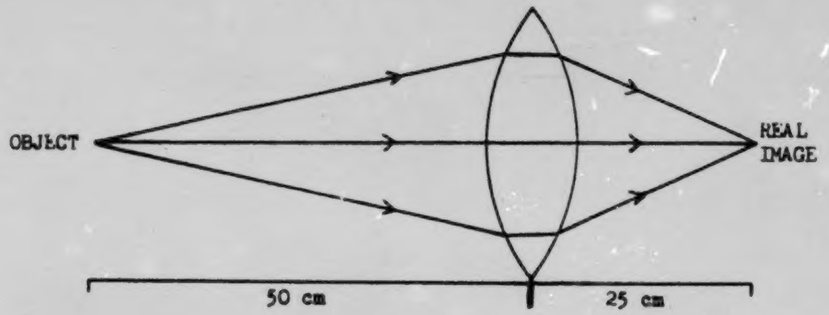


Figure 31

First we must determine the dioptric power of the divergent wavefront entering the lens. If we were to have a lens that focused 50 cm away, how strong would it be? $D = \frac{100}{50} = 2.00D$. So by applying the law of reversibility we can say that the light entering the lens is diverging at that point at a rate of -2.00 diopters. So the lens in the problem must have at least +2.00 of power to neutralize the -2.00D wavefront entering it.

Then we consider how much power the wavefront leaving the lens has. The rays focus light 25 cm away so the light is converging at a rate of $D = \frac{100}{25} = +4.00D$.

In total then we have -2.00D light entering the lens and +4.00D light leaving it. The lens must have +2.00D to neutralize the divergent light entering and another +4.00D to converge the light 25cm away. Thus the total power of the lens is +6.00D.

This process is covered by the formula

$D_T = D(\text{image}) - D\ (\text{object})$

Where D_T is the total power of the unknown lens, D (image) is the reciprocal of the image distance, and D (object) is the reciprocal of the object distance. Recall that the reciprocal of a focal length (image distance) is the conversion to diopters.

Repeating the same problem by substituting into the formula looks like this:

$Di = \frac{100}{fi(cm)} = \frac{100}{25} = +4.00D$ (Plus because the rays are convergent)

$Do = \frac{100}{fo(cm)} = \frac{100}{50} = -2.00D$ (Minus because the rays are divergent)

Then D_T = D image - D object

$= +4.00 - (-2.00) = +4.00 + 2.00 = +6.00D$

Note that because the distances were in centimeters we used the automatic conversion factor of 100 in the numerator. Also note that the object wavepower was minus and the image wavepower was plus. Also note that the double minus became an overall plus.

We'll figure another example of an object 16 inches away forming a virtual image 10 inches to the left of the lens. This is diagrammed in figure 32.

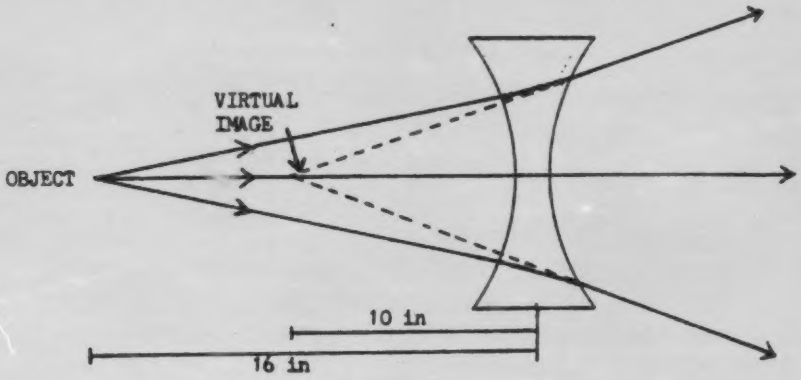


Figure 32

The light entering the lens is divergent D = $\frac{40}{16}$ = - 2.50D, and the light leaving the lens is divergent D = $\frac{40}{10}$ = -4.00D. This means that the light leaving the lens has changed -1.50D worth. This is the power of the lens.

EXERCISE 15

Compute the power of the following lenses.

Answers to questions 1 and 2 may be found in the back of this SW.

1. Light from an object 500 mm from a lens is focused into a real image 200 mm away.

2. A concave lens focuses light from an object 1 meter away into a virtual image 20 inches from the lens.

3. A convex lens focuses light from an object 80 inches away into a real image 20 inches away.

4. Light strikes a lens converging at a rate of 3.00D. The lens focuses the light 40 inches away. What is the power of this lens. (Note: you cannot use the formula on this problem, you have to think it out.)

ABSORPTION AND POLARIZATION

Absorption

If you recall, we agreed to speak of emission and absorption in terms of the particle theory, so for the purposes of explaining absorption we will regard light in terms of photons.

Absorption is the process in which radiant energy is converted into another energy form - usually heat. When a photon, or packet of energy, strikes matter it will strike an individual atom. The atom is made up of a nucleus with electrons rotating around the central nucleus, as shown in figure 33 below.

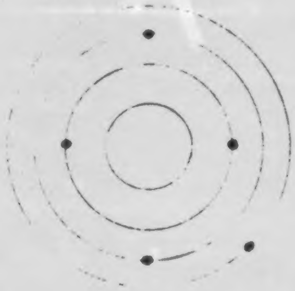
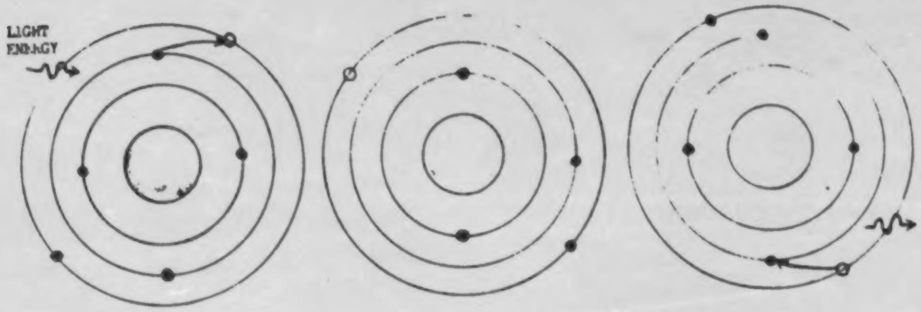


Figure 33

figure 33

Each of the electron orbits has a different energy level, in other words an electron in the second orbit will have a greater energy level than an electron in the innermost orbit. A photon will have its energy absorbed into an atom by "pumping up" an electron into a higher energy level. This is shown in figure 34 below.



Electron is pumped up.

Entire atom now has an overall higher energy potential

Electron drops back down to a lower giving off energy.

Figure 34

When an electron is pumped up to a higher energy level the entire atom also has an overall higher energy level. Usually the electron will drop back down to its lower energy level quite quickly and emit energy in another form-usually heat. The energy may be rereleased as electromagnetic energy of a different wavelength than the exciting stimulus. Usually the rereleased wavelength is longer than the original, so ultraviolet radiation is seen as visible and visible is changed to thermal. This is why objects sitting out in the sun (visible light) get warm.

Sometimes, the absorbed light "pumps up" the energy level so much that light is re-emitted even after the exciting light has been discontinued. This is the case with radium and fluorescent paint such as you see on a luminous watch dial.

A few substances will convert light energy to electrical energy or cause what is known as a photovoltaic or photoelectric effect. Day - night automatic switches employ this effect as do electric eye doors that open and close when a light beam going to the photoelectric cell is interrupted by an object.

When a substance will absorb some wavelengths but not others this is called SELECTIVE ABSORBTION. Pigments reflect their characteristic color but absorb most other wavelengths. A red car, for example, reflects red and absorbs most other wavelengths. Filters selectively absorb light because they transmit their characteristic color and absorb all other wavelengths. Absorption will be discussed again later in this text in the realm of ophthalmic optics and lenses.

Polarization

The limiting of light transmission to one major meridian is called POLARIZATION. We know that light normally vibrates in all planes, perpendicular to its direction of travel but a polarizing device just allows light to vibrate in one meridian.

If one was to attach a rope to a post and shake it in any meridian you would get waves passing along the rope in that specific meridian. If, however, you pass the rope through a picket fence with vertical slats, only vertical vibrations will pass through, the other vibrations will be blocked out. This analogy of polarization is quite accurate as most common polarizing devices have a grid formed by the alignment of molecules in the material.

To determine the plane of vibration of polarized light we can use another piece of polarizing material that has already been calibrated and orientate it so that no light passes through. This second calibrated polarizer is called an ANALYZER. When no light is transmitted the light is polarized in a meridian perpendicular to the transmission meridian of the analyzer.

E. H. Land invented a process for producing inexpensive, high-quality polarizing material that is now in wide use in sunglasses for reducing glare. Glare is made up of relatively bright, diffuse light. Polaroid materials reduce glare because they only allow regularly polarized light to enter the eye.

EXERCISE 16

Circle the correct answer.

1. When light energy is absorbed it is usually re-emitted as (heat)(light)(electricity).

2. A red pigment (absorbs)(reflects)(transmits) red wavelengths.

3. A green filter (absorbs)(reflects)(transmitts) green light.

4. The limiting of light transmission to one major meridian is called (absorption)(reflection)(polarization)(analyzation).

5. A device used to determine the plane of transmission is called a(n) (polarizer)(polarizee)(analyzer).

OPHTHALMIC OPTICS

OBJECTIVES

Upon completion of this study guide and workbook you will be able to:

1. Describe manufacture, forms and types of ophthalmic lenses.
2. Describe refractive qualities of ophthalmic lenses.
3. Calculate prismatic effect of an ophthalmic lens.
4. Explain the relationship between vertex distance and the vertex/effective power of ophthalmic lenses.
5. Depict aberrations inherent in ophthalmic lenses.
6. Explain the elements contained within an ophthalmic prescription.
7. Transpose the spherocylinder form of each prescription so that it corresponds to the requirements for ordering spectacles set forth in AFR 167-3.
8. Identify special purpose lenses.

INTRODUCTION

Ophthalmic optics is that portion of optics concerned with applications which pertain to the eye. Many of the principles covered in this section will have direct bearing on your duties in the clinic. Let's start off by looking at the manufacture and requirements of ophthalmic glass.

INFORMATION

MANUFACTURE, FORMS AND TYPES OF OPHTHALMIC LENSES

Manufacture

In the United States we find that the glass industry dates back to 1607 when Captain John Smith established it in the Colony of Virginia, near Jamestown. The first attempt to manufacture glass suitable for optical use was made about 1889, when a plant was established at Elwood, Indiana, by Mr. Macbeth of the Macbeth-Evans Company. Work was soon abandoned, however, and the next attempt was made by the Bausch Lomb Optical Company at Rochester, New York. Under the direction of Mr. William Bausch some glass of fair quality was produced in 1912, but it was not until 1915 that glass of good quality was produced in quantity.

TYPES OF OPHTHALMIC GLASS. Ophthalmic glasses may be divided according to use and optical characteristics into the following classifications: (1) Ophthalmic crown, (2) Flint or lead glasses, (3) Barium and Baryta flint glasses, (4) Colored glasses, including tinted and special absorption glasses.

Clear crown glass, the type most used for ophthalmic lenses, is essentially a soda-lime-silica glass somewhat similar in composition to the better grades of plate glass with the necessary refinements added to obtain optical quality. In general it contains about 70% sand, 11 to 13% calcium oxide or lime, and 14 to 16% sodium oxide or soda, with small percentages of potassium, borax, antimony and arsenic being used to aid in improving the quality. It must have the correct total expansion from room temperature to softening temperature to fuse in making bifocal lenses without developing strain between the two glasses. The composition must be carefully controlled so as to keep the index of refraction the same or within narrow limits from melt to melt, and to prevent the glass from forming a fog or cloudy condition during the fusion process. It must have a softening point at high enough temperature to prevent distortion of the curve under the disc during the bifocal fusing process.

Flint or lead glasses usually contain from 45 to 65 per cent oxide of lead with the lead content being increased to obtain an increase in the index of refraction. The other ingredients are generally a mixture of 7 to 10 per cent soda and potash with the remainder of the batch being made up of sand. The chief use of these glasses is in making the Kryptok series of bifocal lenses which are fused with ophthalmic crown glass. These glasses are characterized by having a brilliant lustre, high specific gravity, high refractive index, high dispersion and low softening temperature. They are exceptionally well suited for the making of bifocal lenses, except for the extra amount of color aberration seen through the reading portion of flint segment.

Barium glasses usually contain from 25 to 40 per cent oxide of barium, which has the same effect of increasing the index of refraction as the lead oxide, but does not increase the dispersion as much. The other raw materials generally used are sand and small percentages of the oxides of zinc, aluminum, boron, lime, antimony and zirconium. The chief use of these glasses in ophthalmic work is in making a series of bifocal lenses with low dispersion in the segment glasses. Panoptik and other Orthogon bifocals have all of the advantages of the Kryptok series and none of the disadvantages, as they are free from color fringes.

The colored and selective absorption glasses are usually made by the addition of metallic oxides, as a raw material, to the regular crown glass batch before the melting process. The use of cobalt oxide produces a blue, chromium oxide-green, manganese - violet, uranium-yellow, and combinations of these and other oxides may be used to produce tinted glasses. Other materials, such as cerium oxide, will produce a glass having absorption in the ultra-violet, and still others produce strong absorption bands in the visible spectrum. Iron oxide, under properly controlled melting conditions, will produce infra-red absorption.

Requirements for Ophthalmic Glass

Ophthalmic glass used exclusively for spectacles and eyeglasses is generally known as optical glass because of the high precision demanded of it, and the necessity of maintaining accurate control over the entire manufacturing process. The requirements are very definite and rigid although in general quite different from those of optical glass used for prisms and lenses in microscopes and other optical instruments.

Process for Manufacture of Ophthalmic Glass. All types of ophthalmic glass, constituted mainly of sand or silica mixed with other chemicals, are formed by uniting the raw materials by fusion or melting at relatively high temperature.

Glasses could be made by the fusion of silica alone. In glass manufacture the sand is fused with either soda or potash (or a mixture of the two) which act as fluxes to accelerate the melting process. Added also are one or more alkaline earth materials, such as the oxides of lime, lead, barium, or zinc. These not only help make the glass durable and permanent but also make possible the various combinations of optical and physical properties desired.

Limestone must also come from pure deposits. Most of the other ingredients are pure products of the chemical industry. The raw materials are accurately weighed out according to an exact formula known to give the desired properties to the finished glass. These materials, now known as the "batch," are thoroughly mixed by a mechanical mixer quite similar to the familiar concrete mixer but lined to prevent contamination from metal parts. To this mixture is usually added a small amount of rejected glass of the same type, known as "cullet." Cullet, having already been melted once, softens more quickly than the batch mixture and aids the melting and fining operation.

Today there are two major methods of making glass for ophthalmic lenses: The continuous flow process for glass types wanted in quantity; the traditional individual batch method used for glasses with special qualities.

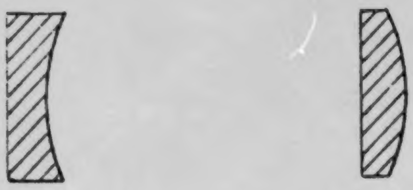
As the rough lens blanks cool, the lot is systematically sampled for control specimens. These lens samples are checked for optical and physical properties, particularly refractive index. If any deviations are discovered, the mixture, control settings, or both are corrected.

Fabricating the Lens. The rough lens blanks are then sent to the grinding area where a factory curve (Base Curve) is ground on. The lens is then polished. When the lens blank is selected for a prescription, the remaining power curves are added at a surfacing area and then the lens is placed in an edging machine that will shape it to fit an appropriate frame.

Forms of Lenses

The physical form of an ophthalmic lens is determined by center thickness and surface curvature. The same power lenses may be made in different forms to minimize certain aberrations.

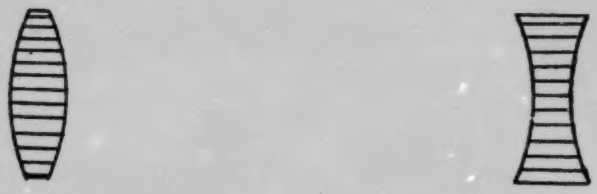
The first lens form we need discuss is the flat or plano surface with zero (o) power. The other surface can be either convex (bulging out) or concave (caved in). Such lenses are called PLANO-CONVEX or PLANO-CONCAVE illustrated in figure 35.



PLANO-CONCAVE PLANO-CONVEX

Figure 35

When both surfaces are of the same type of power, these lenses are called BICONVEX (plus (+) power) or BICONCAVE (minus (-) power). The advantages of these lenses is that they can incorporate high power in a single lens. The disadvantage is that they amplify certain aberrations. The lenses are shown in figure 36.

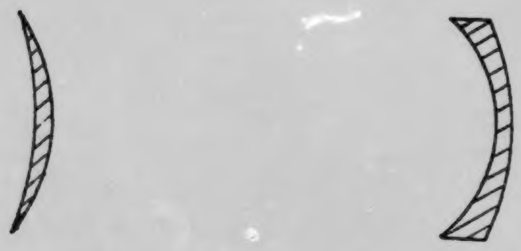


BICONVEX

BICONCAVE

Figure 36

The most common opthalmic lenses are of the MENISCUS variety. Meniscus lenses have surfaces of opposite power and the same sign radii of curvature. When speaking of meniscus lenses, THE SECOND TERM IN THE NAME IDENTIFIES WHETHER THE LENS IS PLUS OR MINUS. Thus a CONVEXO-CONCAVE is divergent or minus and a CONCAVO-CONVEX is convergent or plus. These lenses are illustrated below in figure 37.



POSITIVE MENISCUS
CONCAVO-CONVEX

NEGATIVE MENISCUS
CONVEXO-CONCAVE

Figure 37

Types of Lenses

Lenses are divided up into two categories, SINGLE VISION and MULTIFOCALS. A single vision lens is a lens which places only one primary focus on the retina of the eye. A multifocal is simply a lens that allows the eye to focus at two or more distances. The different foci are due to additional segments that are either ground in or fused into the main lens.

Both single vision and multifocals may take any one of the following forms: spherical, cylindrical, or spherocylindrical.

A spherical lens consists of two surfaces which are segments of spheres. Thus they are equally curved all over which gives them the same power in all meridians.

A cylinder has one or both surfaces which are segments of a cylinder. This means that one meridian is flat thus having zero (o) power, and the other major meridian is curved meaning it does have power.

A spherocylindrical (toric)(compound) lens has a meridian of minimum power and a meridian of maximum power perpendicular to each other. A toric lens differs from a simple cylinder in that it does have power in all meridians (maximum and minimum) whereas a simple cylinder has zero (o) power in one meridian and maximum in the other.

The sphere, cylinder and spherocylinder will be discussed more fully in the section after base curves.

Base Curves

Every lens we have discussed so far has had 2 surfaces but possibly more than 2 curves. A spherocylinder, for example, has 3 curves - a spherical curve on one surface and two curves (one minimum power, one maximum power) on the other surface. The base curve of a lens is the fixed curve usually ground on at the factory. In some cases the base curve must be reordered exactly to minimize patient adaptation effects. The following is a listing of the base curves for military lenses:

1. Single vision spheres - the base curve is the weaker curved surface i.e. the concave side of a plus (+) lens and the convex side of a minus lens.

2. Single vision spherocylinders - the flatter (weaker curve) on the toric front for plus cylinder form lenses. In minus cylinder form lenses the base curve is the spherical front. In other words, the weakest curve on the front surface.

3. Multifocals - the base curve is the spherical curve on the side containing the segment.

Now that you are thoroughly confused let's try and explain what we mean. An instrument called a Geneva Lens Measure can measure the curvature(s) of an individual lens surface and converts that curvature into diopters. This instrument is used primarily to measure base curves but to do this one has to know which curve on which surface, to measure. This was given to you above but we will take each one individually and explain it.

A single vision sphere has two spherical curves, one on each surface. This means that a plus sphere is plus because the convex (+) surface has more power than the concave or minus surface. Consequently the weaker curved surface (base curve) is the concave (-) surface. It doesn't matter where on that surface you measure because it is spherical and thus has the same power in all meridians. On the other hand, a minus sphere has more power on the concave (-) surface than the convex (+) surface thus the weaker curved surface (base curve) is the convex (+) surface.

A single vision spherocylinder has 3 curves. One surface is spherical and the other surface is toric (two curves). If the lens is ground in plus cylinder, it means that the toric surface is the front (+) surface and the spherical surface is the back (-) surface.

On the other hand, if the lens is ground in minus cylinder form it means that the cylindrical (toric) surface is the minus (back) surface and the spherical surface will then be on the front.

Now refer back to the base curve of a single vision spherocylinder. It says that the base curve is a flatter curve on the toric front if the lens is in plus cylinder form. Meaning that there are two curves on the front and one (spherical) curve on the back. The base curve is the weakest curve on the front. If the lens is ground in minus cylinder then the front curve is spherical, and that is the base curve.

Multifocals have 1 or more additional segments, usually for reading. They usually have the segments on the front surface, in which case the cylinder will be ground onto the back surface. A person's cylindrical correction does not change at the nearpoint so we place the cylinder on the back surface so that when the segment(s) are fused in the front, the cylinder (on the back) is still intact. If the segments were fused on the side containing the cylinder, the cylinder power would be lost through the additional segments. In the military, most of our multifocals are on the front surface, which means that the front surface is spherical. This spherical curve, in the distance portion, is the base curve.

If the additional segment(s) are on the back surface then the distance portion of the back will be spherical and this curve would be its base curve.

EXERCISE 17

1. List the three major types of ophthalmic glass.

    a.

    b.

    c.

2. Name two methods for manufacture of ophthalmic glass.

    a.

    b.

3. When speaking of meniscus lenses, the (first)(last) word denotes the power of the lens. (Cross out the incorrect answer.)

4. A negative meniscus lens may also be called a _________ - ___________ lens.

5. There are two major categories of lenses, single vision and bifocal. Each of these may take any one of 3 forms. Name them:

a.

b.

c.

6. Which meridians have +5.00D of power on a +5.00D spherical lens surface?

7. A spherocylindrical lens has __________ curves. Describe where the curves would be located if the lens were ground in plus cylinder form.

8. Explain why, in a multifocal, the cylinder is ground on the other surface from the segment(s).

REFRACTIVE QUALITIES OF OPHTHALMIC LENSES

Up until this point, we have discussed lenses only in respect to their effects upon light. Ophthalmic lenses, however, will be discussed in reference to their effects upon the eyes. We will start off by discussing terminology just to ensure that we are all on the same wavelength.

Terminology

OPTICAL CENTER. That point on a lens where light passes without resultant deviation. This point on a lens is not necessarily the geometric (physical) center, although it may be.

MERIDIAN. An imaginary line drawn through the optical center of a lens. When we are speaking about how much power a lens has in any given area, we are speaking about a meridian.

DIOPTER. The power of an ophthalmic lens is always measured in diopters.

SURFACE-CURVATURE. The major factor influencing power in any meridian, when you consider one lens, since the index of refraction is constant throughout the lens.

Ophthalmic Lenses

We have two major categories of ophthalmic lenses - single vision and multifocals. These, however, may be subdivided into spheres, cylinders, and spherocylinders. Let us take each one individually and look at their characteristics a little more closely.

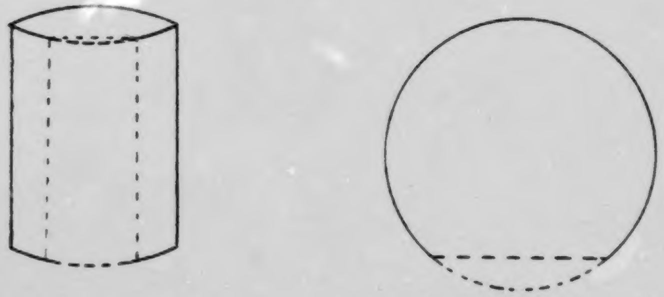
SPHERES. A spherical lens is a lens that has both surfaces that are segments of spheres. They are characterized by equal radii of curvature (equal curvature), and therefore, equal power in all meridians. This does not necessarily mean that the front and back surfaces have the same curvature, it means that on each individual surface the curvature will be the same anywhere on that surface.

Most ophthalmic lenses are of the meniscus variety, meaning that the front surface is plus and the back surface is minus. A plus sphere will have more power on the front surface than it will on the back surface. This means that a plus sphere will have a real point focus.

A negative sphere will have more power on the back surface than it will on the front surface. A negative sphere will form a virtual point focus.

Plano (0.00D) spheres neither converge nor diverge light. They are also of the meniscus variety but the back surface and the front surface will have the same curvature, thus both will have the same amount of power but of opposite signs.

CYLINDERS. A cylindrical lens gets its name from its resemblance to the side cut off a cylinder. Cylinders are characterized by having maximum power in one meridian and zero (o) power in the meridian 90° away. The zero (o) power meridian is called the AXIS meridian.



Dotted lines represent a section cut out of a cylinder forming a simple cylindrical lens.

Looking down through a cylinder. Dotted lines mark the lens section.

Figure 38

The power of this lens to bend light rays, when its axis is in the vertical position, is in the horizontal meridian only; no refraction is produced in the vertical plane. The reason that refraction occurs 90° away from the axis is because the lens has curvature in that meridian, whereas the axis meridian is flat, having zero (o) power. Cylinders are a major part of the study of ophthalmic optics so it would be well worthwhile to know this section well. Figure 39 is a simple cylinder. Study this diagram well and note the curvatures in the horizontal and vertical meridians and their respective effects on light rays.

It should be noted that cylinder axes may be located anywhere between 001° ⟶ 180°. Cylinder axes are not restricted to 90° and 180° positions.

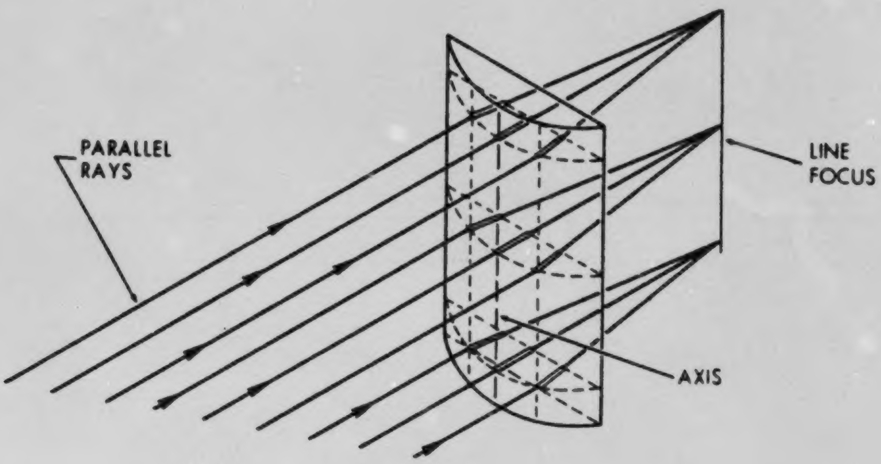


Figure 39

In the figure above, we can tell that there is zero power along the axis as the three sets of rays are not bent in the axis meridian, only in the horizontal meridian are the rays bent to a focus. The lens pictured in figure 39 is a CONVERGENT cylindrical lens because the lens converges the light to form a REAL LINE FOCUS.

CONVERGENT CYLINDERS. Convergent lenses are used rather extensively in spectacles and also for magnifying verniers (slide rule type) scales on instruments.

Rays striking perpendicular (90° away from) to the cylinder axis are refracted as they pass through the lens and converge at a point beyond the lens, forming a LINE FOCUS PARALLEL TO THE CYLINDER AXIS.

DIVERGENT CYLINDERS. A divergent cylindrical lens acts somewhat like a divergent spherical lens, EXCEPT that a VIRTUAL LINE IMAGE IS FORMED PARALLEL TO THE CYLINDER AXIS.

SPHEROCYLINDERS. We have discussed the effects on light of both spheres and cylinders. We said that spheres produce point foci and cylinders produce line foci parallel to the cylinder axes. A SPHEROCYLINDRICAL LENS, being a combination of a simple sphere and a cylinder, acts upon light in a manner similar to both lenses. A spherocylindrical lens may also be called a TORIC or COMPOUND lens.

In this lens, there is still an axis of most power and an axis of least power located 90° away from each other. The light rays striking each axis are considered separated. Since the axes are of differing powers, the light will focus at different distances from the lens.

A spherocylindrical lens forms a figure known as Sturm's Conoid, which is characterized by two line foci at right angles to each other, and a circle of least confusion located at the dioptric midpoint between the line foci.

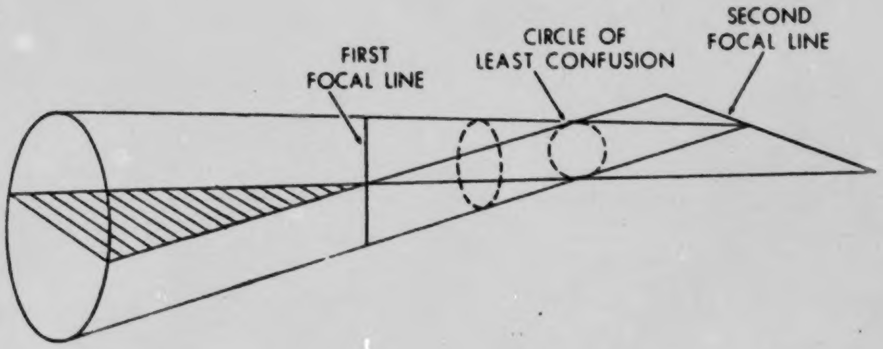


Figure 40

We make break down Sturm's Conoid into two diagrams as the complete diagram is somewhat difficult to comprehend, to put it mildly.

First, let us consider the cylinder portion of the spherocylinder. We know that a cylinder will bend light to form a line focus parallel to the axis.

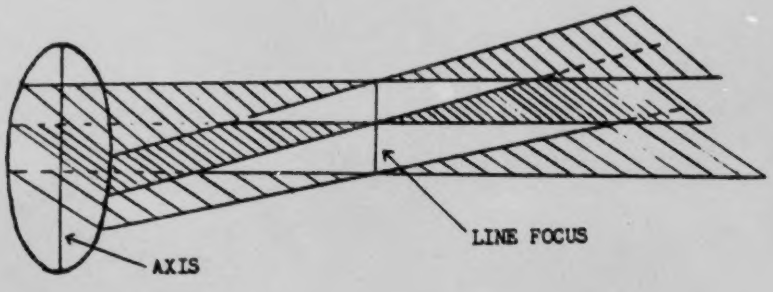


Figure 41

You can see the tiers of light rays are parallel. If you can imagine that many, many light rays are passing through the lens and forming a line focus, where the light rays are refracted or bent along the power meridian (90° away from the axis).

If we then put power in all meridians, it would be like adding sphere power. Let us now look at the two meridians that we are interested in, first, the power meridan 90° away from the axis. The added power would place the focus closer if the sphere was plus or further away if the sphere was minus. The line focus formed parallel to the axis of the cylinder would have a focal distance equal to THE ALGEBRAIC SUM OF THE SPHERE AND CYLINDER POWER IN THE MAXIMUM POWER MERIDIAN, that is, 90° away from the axis.

Now, let us look at the power in the axis meridian. The cylinder part of the lens has no power in that meridian, we only have sphere power. This sphere power then will converge the tiers formed by the cylinder. This will cause a line focus beyond the cylinder line focus where the tiers cross. They will cross at the FOCAL LENGTH OF THE SPHERE.

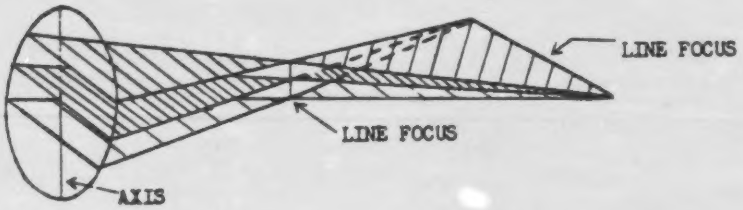


Figure 42

If you now refer back to Figure 40, this is what the sum total of both broken down drawings looks like. Notice the circle of least confusion. This is the DIOPTRIC MID-POINT between the two line foci.

So a spherocylinder has a meridian of minimum power (the axis meridian) and a meridian of maximum power 90° apart.

Spherical Equivalent

Let us suppose that a person has broken his last pair of glasses, and he must drive a bus the next day. His SPHEROCYLINDRICAL prescription is such that he cannot see without his glasses. The lab takes a couple of days even on a telephoned order, what do you do? As a temporary measure, the best thing to do would be to attempt to give this patient his "SPHERICAL EQUIVALENT." A spherical equivalent is a spherical lens that places the patient's vision in the circle of least confusion. This will give the patient adequate vision in most cases and get him by until an accurate pair of spectacles can be fabricated.

Now, where do you get these spheres and how do you figure out which ones to give? You can collect a good selection of spheres from spectacles that are ordered and not picked up and some others from spectacles which have been turned in.

Figuring out what power sphere to give a patient is relatively simple. TAKE ONE HALF OF THE CYLINDER POWER AND ALGEBRAICALLY ADD THIS TO THE SPHERE POWER.

EXAMPLES:

1. Right eye (O.D.) -3.00D sph = +1.50 cyl axis 90°
   Left eye (O.S.) -2.50D sph = +1.00 cyl axis 75°

   Spherical equivalents:

   Right eye (O.D.) $-3.00 + [\frac{+1.50}{2}] = -300 + (+0.75)$

   $= -2.25$D sphere

   Left eye (O.S.) -2.50D sph $+ [\frac{+1.00}{2}] = -250 + (+050)$

   $= -2.00$D sphere

2. Right eye (O.D.) +4.25D sph = +2.00 cyl axis 45°
   Left eye (O.S.) +3.50D sph = +1.00 cyl axis 155°

   Spherical equivalents:

   Right eye (O.D.) $+ 4.25 + [\frac{+2.00}{2}] = +4.25 + [+1.00]$

   $= +5.25$D sphere

   Left eye (O.S.) $+3.50 + [\frac{+100}{2}] = +3.50 [+0.50]$

   $= +4.00$D sphere

Remember that a spherical lens has equal power in all meridians and thus will never have an axis.

EXERCISE 18

1. Define "optical center."

2. Define "meridian."

3. What type of focus will a negative sphere produce?

4. A simple cylinder has _________ power along the axis meridian and __________ power 90° away from the axis.

5. A spherocylinder has an axis meridian of ______________ power and a meridian of ______________________ power 90° away.

6. A negative sphere will normally have ______________________ power on the back surface (i.e., the ocular surface).

7. Cylinder axis may be located between __________ and _____________ degrees.

8. Compute the spherical equivalents of the following lenses. Answers to questions 8a - 8c may be found in the back of this SW.

a. -3.25 sph - 2.00 cyl axis 175°

b. +5.50 sph - 1.50 cyl axis 122°

c. +1.25 sph + 2.50 cyl axis 081°

d. -2.00 sph + 1.50 cyl axis 045°

e. +3.75 sph + 4.00 cyl axis 090°

f. -5.50 sph - 0.50 cyl axis 006°

g. +6.00 sph -1.00 cyl axis 132°

PRISMATIC EFFECT

Prisms are sometimes prescribed in ophthalmic corrections, therefore you should understand fully how prisms act in controlling the direction of light. Let us begin by looking at the characteristics of a prism.

The Prism

A prism is an optical element whose surfaces are flat BUT AT LEAST TWO OF WHICH ARE NOT PARALLEL. The tip of a prism is called the APEX and the bottom is called the BASE.

The laws of refraction apply to prisms. At the first surface the light is bent toward the normal and at the second surface the light is bent away from the normal. The net result is a DEVIATION TOWARDS THE BASE OF THE PRISM. Deviation is the term used to denote refraction through a prism. Observe this in figure 43 below.

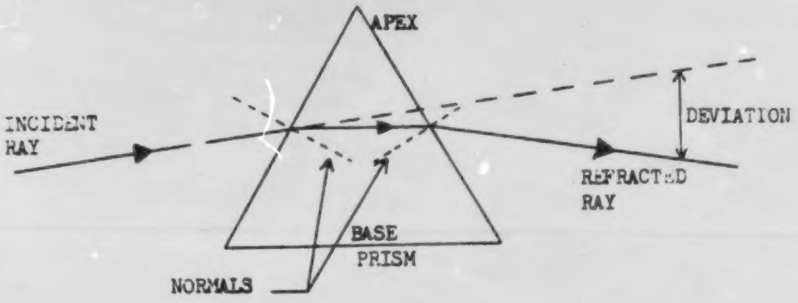
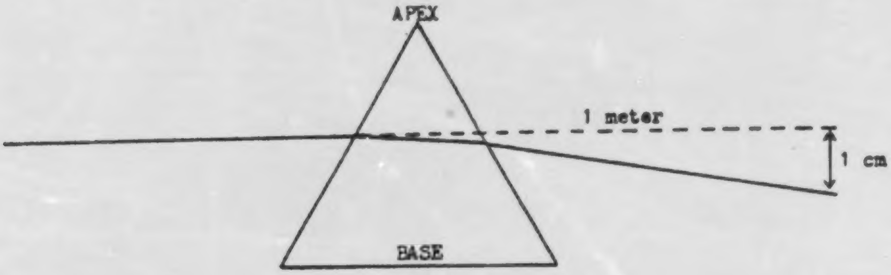


Figure 43

The dioptric strength of a prism is a MEASUREMENT OF THE DISTANCE THAT A REFRACTED RAY OF LIGHT IS DEVIATED FROM THE PATH OF THE INCIDENT RAY AT A DISTANCE OF ONE METER FROM THE PRISM. This power is measured in PRISM DIOPTERS, symbolized by Δ. A prism of one prism diopter (1.00^{Δ}) bends light to such an extent that when a refracted ray travels 1 meter beyond the prism it is deviated a distance of 1 cm from the path of the incident ray. See figure 44 below.



ONE PRISM DIOPTER

Figure 44

If one was to measure the deviation of the one prism diopter prism at a distance of two meters it would be 2 cm. A two prism diopter (2.00^{Δ}) prism will deviate light 2 cm at 1 meter, 4 cm at 2 meters, 10 cm at 5 meters and so on.

You can think of deviation the same way as a rocket. If the rocket is aimed wrong on the ground, the farther it travels, the farther off course it will be.

A prism will affect the ability of a patient to place where an object is located. The eyes have the capability of perceiving where light is coming from, thus if you look at figure 45 below, you can see that the eye thinks the light is coming more from the apex than from the base. It thus places the image more toward the apex of the prism.

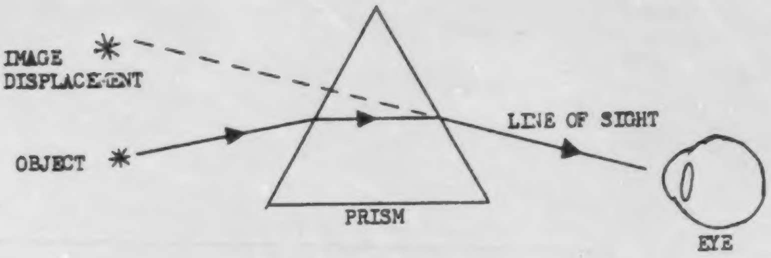


Figure 45

So we have two major characteristics of prisms that never vary and should be remembered.

1. A PRISM ALWAYS DEVIATES LIGHT RAYS TOWARDS THE BASE OF THE PRISM.
2. OBJECTS SEEN THROUGH A PRISM APPEAR TO BE DISPLACED TOWARD THE APEX OF THE PRISM.

Prismatic Effect Through Lenses

If two prisms are placed base to base, the light rays striking the front surfaces of the prisms will be deviated toward the base of each prism and upon emerging from the prisms will be further deviated toward the base resulting in the rays converging to a focus at a given point. See figure 46 below.

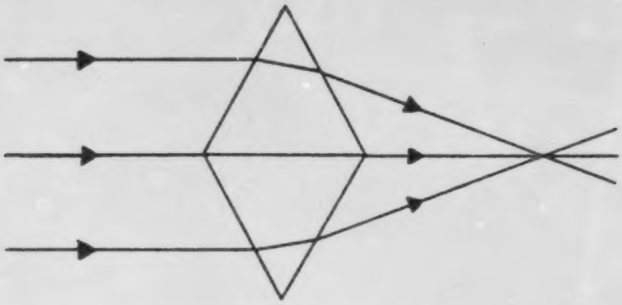


Figure 46

If we then took the two prisms, glued the bases together, and rounded off the edges until they were evenly curved, the result would be an optical element known as a CONVERGENT or PLUS LENS.

When rays of light strike the two prisms (base to base), they do not all focus at one point, whereas the curvature of the CONVERGENT LENS is so designed as to produce a single point focus. See illustration 47 below.

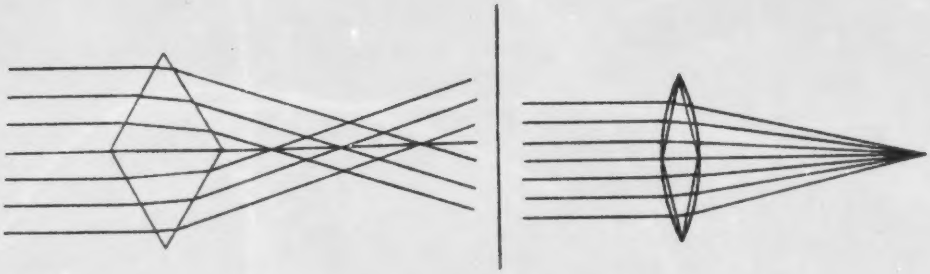
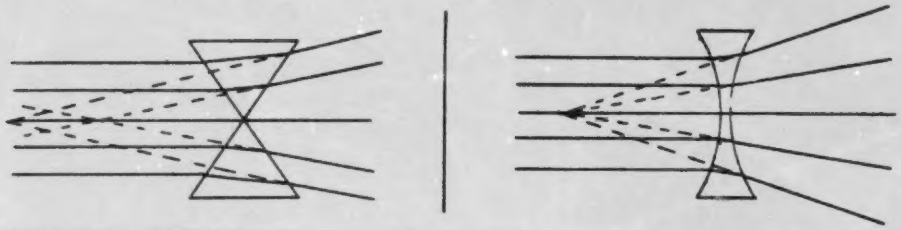


Figure 47

Picture a convergent lens then as two prisms base to base that has been rounded off. NOTE: A convergent lens is THICKER IN THE MIDDLE THAN AT THE EDGES, but it may take many forms. It could be: biconvex - both surfaces convex; plano-convex - one surface flat, the other convex; meniscus - one surface concave, the other convex, the convex surface having more power than the concave in a convergent meniscus lens.

We said that a plus lens could be thought of as two prisms base to base that have been rounded off. Equally a minus (divergent) lens can be thought of as two prisms APEX TO APEX that have been rounded off. Remembering that light is deviated through a prism toward the base, we see that the bases are away from the optical center (where the apexes meet); therefore, light is made divergent or deviated outward. When the two prisms apex to apex are rounded off, we get an imaginary point focus to the left of the lens by tracing back lines from the refracted rays. This is called a VIRTUAL FOCUS.



Multiple VIRTUAL Foci

Single VIRTUAL Focus

Figure 48

Minus lenses are always THICKER AT THE EDGES THAN IN THE MIDDLE. Again they may take many forms. Plano concave - flat on one surface, concave on the other. BICONCAVE - both surfaces are concave. DIVERGENT MENISCUS - one surface is convex, the other is concave. The concave surface has more power (more curved), thus giving us a lens thicker at the edge than in the middle, with divergent power.

We can see then that lenses act like prisms; plus (+) lenses act like two (2) prisms base to base. and minus lenses act like two prisms apex to apex. Thus a patient will receive prismatic effect from a lens UNLESS HE LOOKS THROUGH THE OPTICAL CENTER (O.C.) OF THE LENS. THE OPTICAL CENTER OF A LENS IS WHERE LIGHT PASSES WITHOUT RESULTANT DEVIATION.

If we review figure 47 we can see that, in a plus (+) lens, the only undeviated light ray passes through the place where the two bases meet. In figure 48 the only undeviated light ray passes through the place where the apexes of the two prisms meet, in a minus lens.

Sometimes an ophthalmic prescription will require a prism to correct certain muscle anomalies, in which case the prism can be supplied in one of two ways.

1. A prism may be actually ground into the lens, or

2. The lens may be placed in front of the eye in such a way as to use the prismatic characteristics of the lens power to create the desired effect.

It is the last method that particularly interests us. A prism may not be wanted in an ophthalmic correction; therefore, we must have the visual axes aligned exactly with the optical center of the lens in order to prevent unwanted prismatic effect.

We can determine the amount of prismatic effect created by a lens DECENTERED (optical center of lens NOT aligned with the visual axis) by the use of the following formula:

$$\Delta = d(\text{cm}) \times D$$

where Δ equals the amount of prism induced by moving the optical center d, or the distance in centimeters away from center through a lens of D power, D equalling the diopters of lens power.

EXAMPLE:

Suppose that a right eye (O.D.) lens of +1.00D were placed so that the optical center were 4 mm above the patients' line of sight (L.O.S.)

We may diagram this as follows. (Imagine that you are viewing the patient from the side.)

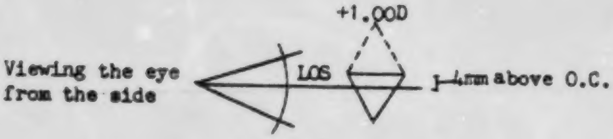


Figure 49

Formula: $\Delta = d\ (\text{cm}) \times D$

$\Delta = 0.4\ \text{cm} \times 1.00\text{D} = 0.4^{\Delta}$ BUOD.

We have shaped the +1.00D lens like two prisms base to base. In figure 49, we can see that the eye is looking through the bottom prism with its BASE UP. Therefore, the prismatic effect is base UP (BU). We can ignore the top prism because the patient is not looking through it.

Let us suppose that the visual axis was above the optical center of the lens. The eye is looking through the top prism with its base DOWN. The prismatic effect is base DOWN (BD).

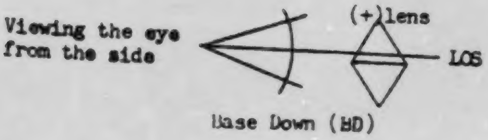

Viewing the eye from the side
(+)lens
LOS
Base Down (BD)

Figure 50

We can draw the same diagrams for minus lenses with the pupils above and below the optical center.

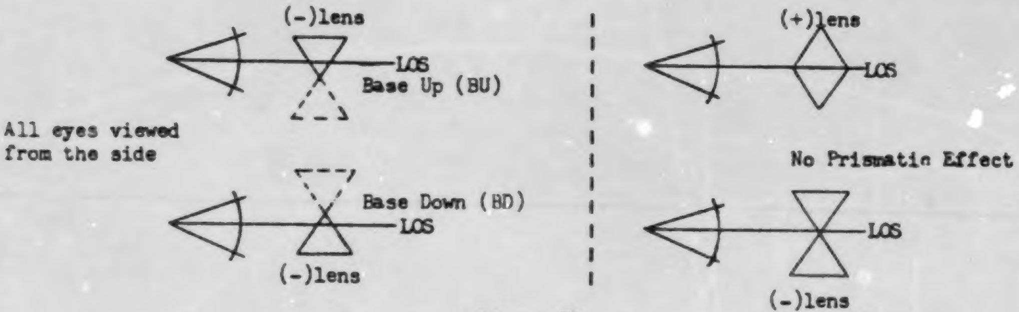

(-)lens
LOS
Base Up (BU)
All eyes viewed from the side
Base Down (BD)
LOS
(-)lens
(+)lens
LOS
No Prismatic Effect
LOS
(-)lens

Figure 51

We figure out what the prismatic effect is by looking to see where the base of the prism is, that the visual axis (line of sight) passes through.

When writing the amount of prism to be included in a spectacle prescription, not only must you write the numerical amount, but you must also include the direction of the base. If the base is up or down, the eye over which the prism is to be placed must also be included.

Thus far we have only spoken of vertical (up or down) prismatic effect, but we know that spherical lenses have power in all meridians including lateral (side to side) meridians. Therefore, we can conclude that lateral prism is possible if the visual axes are not properly aligned horizontally with the optical centers of the lenses. When we speak of lateral prismatic effect we say that the base is either IN, towards the nose of OUT, towards the temple. Below are diagrams showing the prismatic effect produced by placing the optical centers of various lenses in various positions in front of the eyes. Imagine that you are looking down through the top of the person's head.

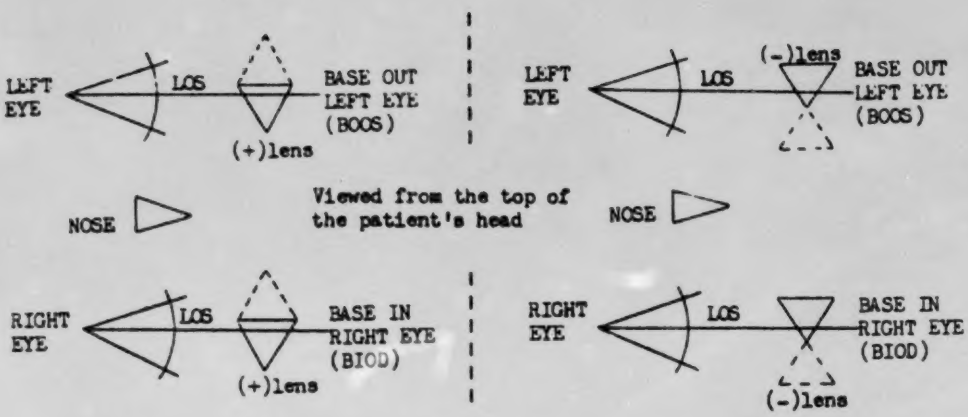
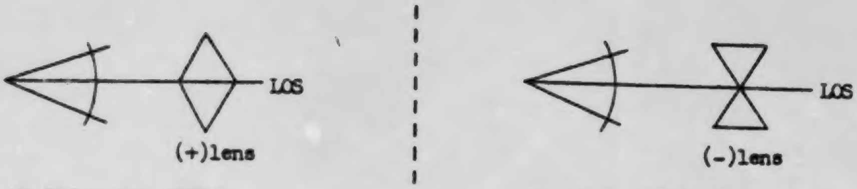

LEFT EYE
LOS
BASE OUT LEFT EYE (BOOS)
(+)lens
LEFT EYE
LOS
(-)lens
BASE OUT LEFT EYE (BOOS)
NOSE
Viewed from the top of the patient's head
NOSE
RIGHT EYE
LOS
BASE IN RIGHT EYE (BIOD)
(+)lens
RIGHT EYE
LOS
BASE IN RIGHT EYE (BIOD)
(-)lens

Figure 52


LOS
(+)lens
LOS
(-)lens

NO PRISMATIC EFFECT

NO PRISMATIC EFFECT

Figure 53

Decentration (Single Vision)

When prism is not wanted by the doctor, we must make sure that the O.C. is directly in front of the eyes. This moving around of the O.C. in the frame can be performed by cutting the lens blank in such a way as to make sure that the finished lenses, inserted into the frame, correspond to the patient's INTER-PUPILLARY DISTANCE. INTERPUPILLARY DISTANCE (PD) is the distance, in mm, between the centers of the patient's pupils.

PD is measured at distance, and also at near, because people converge their eyes when they look close up. So a PD of 67/63 means that when looking at distance his eyes are 67 mm apart but when looking at near his eyes are 63 mm. The distance PD is recorded above the near.

A frame also has a "PD". Frame PD (FPD) is equal to the sum of the EYE SIZE and the BRIDGE SIZE. If a frame has a 44 eye size and a 20 bridge size, then the frame PD is 64 mm.

We have a variety of different spectacles that can be prescribed and we have to decenter the lenses for the distance at which the spectacles are designed to be used. In other words if you give a patient spectacles for distance use, you should decenter his lenses to his distance P.D. If on the other hand if an individual is prescribed reading glasses then you should decenter his lenses to his near PD.

EXAMPLE 1: The patient's PD is 68/65. He is to be fitted with distance spectacles in a 44-20 frame.

PPD 68 mm (Distance)
FPD 64 mm (44 + 20)
4 = 2 out decentration each eye.

The decentration will be "2 out" each eye. There is a 4 mm difference both eyes, which will be a 2 mm difference each eye. The decentration will be "out" because you move the O.C.'s from the FPD (64) out to the PPD (68).

EXAMPLE 2: The patient's P.D. is 64/61. He is to be fitted with distance spectacles in a 46-22 frame.

PPF 64 mm (distance)
FPD 68 mm (46 + 22)
4 = 2 in decentration each eye.

The decentration will be "2 in" each eye. There is a 4 mm difference both eyes, which will be a 2 mm difference each eye. The decentration will be "in" because you move the O.C.'s from the FPD (68) in to the PPD (64).

EXAMPLE 3: The patient's P.D. is 69/65. He is to be fitted with reading spectacles in a 44-24 frame.

PPD 65 mm (near)
FPD 68 mm (44 + 24)
3 mm = 1 1/2 mm in decentration each eye.

The decentration will be 1 1/2 in each eye. There is 3 mm difference both eyes, which will be 1 1/2 mm difference each eye. The decentration will be "in" because you have to move the O.C.'s from the FPD (68) in to the PPD (65).

From these examples we can derive some rules to assist you in figuring single vision decentration.

1. Decentration is always figured for each eye.

2. The distance PD is used for distance glasses and near PD is used for near spectacles.

3. If the PPD is larger than the FPD, the decentration will be OUT.

4. If the FPD is larger than the PPD, the decentration will be IN.

Multifocal Decentration

We have discussed single vision decentration for distance or near glasses, however, multifocals have slightly different requirements due to the individual being prescribed spectacles for distance and near at the same time. In essence all you are going to do is make the O.C.'s of the distance portion of the lens, coincide with the patient's distance PD and at the same time make the O.C.'s of the additional segments coincide with the patient's near PD. This is achieved by determining, on each multifocal, three decentrations; distance, bifocal inset, and total decentration.

Distance decentration is the same as for single vision i.e. FPD computed against the patient's distance PD.

Bifocal inset is the amount that the bifocal O.C. is displaced from the distance O.C. Assuming that the distance O.C.'s match the patient's distance PD then the amount that the eyes move when going from distance to near is the difference between the distance and near PD. For example a patient with a PD of 68/64 goes from 68 (distance) to 64 (near) so each eye moves in 2 mm. Bifocal inset is always in because the eyes always converge to look close up. Suppose a patient has a PD of 63/60 then his bifocal inset will be 1 1/2 in.

Total decentration is the total amount that the bifocal O.C.'s were moved from the FPD. This may be achieved in two ways. You can combine the distance decentration and the bifocal inset i.e. if the PPD is 68/64 and he is fitted with a 46 - 20 frame then the distance decentration is 1 out and the bifocal inset is 2 in. The total decentration then, will be 1 in. Equally we could have arrived at this by comparing the near PD versus the FPD.

PPD 64 (near)
FPD 66 (46-20)
2, 1 in each eye.

EXAMPLE 1: Compute distance, bifocal, and total decentration for a patient with a PD of 72/69, fitted with a 48 - 20 frame.

Distance decentration (distance PD vs FPD) = 2 out
Bifocal decentration (distance PD vs near PD) = 1 1/2 in
Total decentration (FPD vs near PD) = 1/2 out

EXAMPLE 2: Compute distance, bifocal, and total decentration for a patient with a PD of 63/60, fitted with a 46 - 22 frame.

Distance decentration (distance PD vs FPD) = 2 1/2 in.
Bifocal decentration (distance PD vs near PD) = 1 1/2 in.
Total decentration (FPD vs near PD) = 4 in.

Prismatic Effect of Spectacles

We have talked about decentration and how to figure it so that the people in the optical lab, that grind the lenses, will know how to grind them. However, as is the case in most human endeavors, people make mistakes and it will be one of your duties to check the spectacles when they return to your clinic from the optical lab. One of the checks that you will make is for the accuracy of the decentration. This is done by determining the distance between the O.C.'s on an instrument called the lensometer. By determining the distance between O.C.s it is then possible to determine the amount of prismatic effect the patient will receive and also the type, i.e., the base direction. It is quite simply a combination of methods that you already learned in this section. Let us take an example. A patient has been prescribed a set of distance spectacles with -4.00D.O.D. and -5.00D O.S. The spectacles return from the lab with a distance between O.C.'s of 60 mm. The patients PD is 70/67. What will be the induced prismatic effect and the base direction?

The best place to start is with a simple diagram of the situation as shown in figure 54.

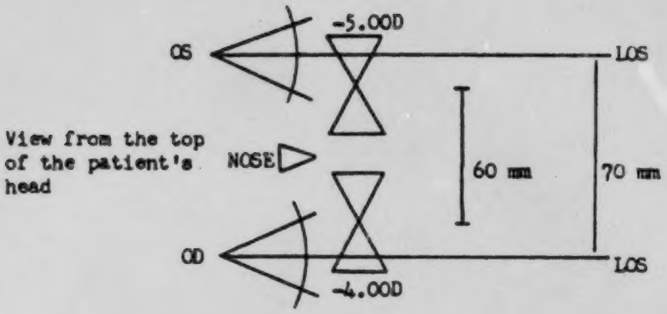


Figure 54

Notice that the patient's L.O.S.'s are 70 mm apart - corresponding to the patient's distance PD. Also note, the O.C.'s of the lenses are inside the patients L.O.S.' and that the prisms were drawn apex to apex because he has minus (-) lenses. We can see that the prisms that he is looking through are Base Out (BO). Our only problem now is to compute the amount of prismatic effect for each eye. This is done using Prentice's prism formula as follows:

Δ O.D. = d(cm) x D
= 0.5 cm x 4.00D
= 2.00^{Δ} BOOD.

Δ O.S. = d(cm) x D
= 0.5 cm x 5.00D
= 2.50^{Δ} BOOS.

The O.C.'s are 60 mm apart and the patient's L.O.S. are 70 mm apart, so there is a 10 mm difference which equals 5 mm each eye. Converting 5 mm to 0.5 cm gives us d (cm). The dioptric power is 4.00D right eye and 5.00D left eye. Notice that we do not write in the signs plus (+) or minus (-) as this is determined in whether we draw our lenses apex to apex (minus) or base to base (plus). Also notice that the answer is written including the base direction as well as the amount and the eye.

Now let's try another sample problem. Suppose a patient is prescribed reading spectacles with +2.00D O.D. and +3.00D O.S. The patient has a PD of 63/60. The spectacles return from the lab with a distance between O.C.'s of 66 mm. What will be the induced prismatic effect and the base direction?

Again, we will diagram the situation before we do anything else.

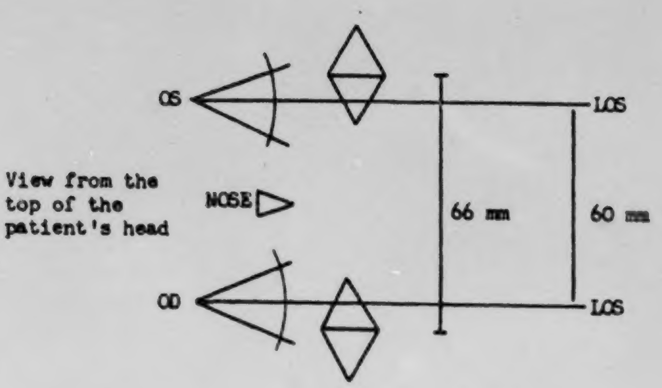


Figure 55

The patient's L.O.S. are 60 mm apart, corresponding to the patient's near PD (because he was prescribed reading spectacles). Note also that the O.C.'s of the lenses (66 mm) are outside of the patient's L.O.S. and that the prisms were drawn base to base because he has plus (+) lenses. We can see that the prisms that he is looking through are Base Out (B.O.). We compute the amount of prismatic effect using Prentice's prism formula as follows:

ΔO.D. = d(cm) x D
= 0.3 cm x 2.00D
= 0.6^{Δ} BOOD

ΔO.S. = d(cm) x D
= 0.3 cm x 3.00D
= 0.9^{Δ} BOOS.

The O.C.'s are 66 mm apart and the patient's L.O.S. are 60 mm so there is a 6 mm difference which equals 3 mm each eye. Converting 3 mm to 0.3 cm gives us d(cm). The dioptric power is 2.00D right eye and 3.00D left eye. Notice that we don't write in the plus (+) signs, as this is taken into account when we draw the lenses base to base.

EXERCISE 19

1. Light is always deviated toward the (base)(apex) of a prism. (Cross out the incorrect answer)

2. How much will a 5.00^{Δ} prism deviate light at distance of 1 meter?

3. Objects seen through a prism appear to be displaced toward the (base)(apex) of the prism. (Cross out the incorrect answer)

4. In terms of prisms, we think of a plus lens as two prisms _______ to ________,

and a minus lens as two prisms __________ to ____________.

5. The only place on an ophthalmic lens where a patient receives zero (o) prismatic

effect is the _______________ _____________________________.

6. What type of prismatic effect will a person receive if they are looking above the O.C. of plus lens?

7. What type of prismatic effect will a person receive if his L.O.S.'s are looking inside of the O.C.'s of minus lenses?

8. Interpupillary distance is measured in ________________________.

9. Frame PD is equal to ______________________ plus ______________________.

10. Name the three types of decentration that are required for multifocal prescriptions.

EXERCISE 20

Given the lens power (D) and the position of the L.O.S. with respect to the O.C. compute the prismatic effect (△) and base direction of the following lenses.

Answers to questions 1-3 may be found in the back of this SW.

1. D = +2.00D.
   L.O.S.: 5 mm above O.C.

2. D = -3.50D
   L.O.S.: 4 mm temporal of O.C.

3. D = +5.25D
   L.O.S.: 6 mm nasal of O.C.

4. D = -6.25D
   L.O.S.: 10 mm below O.C.

5. D = +6.50D
   L.O.S.: 8 mm temporal of O.C.

6. D = +7.00D
   L.O.S.: 7 mm nasal of O.C.

EXERCISE 21

Compute the prismatic effect and base direction of the following spectacles given; the dioptric power (D) each eye, the patient's PD (PPD), and the distance between the O.C.'s when the spectacles return from the optical lab. The answers for questions 1-3 may be found in the back of this SW.

1. Reading glasses

O.D. = +2.50D
O.S. = +2.50D
PPD = 72/68
O.C.'s = 64 mm

2. Distance glasses.

O.D. = -4.25D
O.S. = -4.75D
PPD = 65/62
O.C.'s = 68 mm

3. Distance glasses

O.D. = -2.00D
O.S. = -2.50D
PPD = 68/64
O.C.'s = 60 mm

4. Near glasses

O.D. = +3.00D
O.S. = -1.00D
PPD = 74/70
O.C.'s = 72 mm

5. Distance glasses

O.D. = -6.00D
O.S. = -5.00D
PPD = 68/64
O.C.'s = 68 mm

6. Distance glasses

O.D. = -8.00D
O.S. = -6.00D
PPD = 60/57
O.C.'s = 70 mm

EXERCISE 22

Compute the decentration of each lens, in a pair of single vision spectacles, necessary to eliminate prismatic effect. The frame is the eye size, bridge size, and temple length. PPD is the patient's interpupillary distance. You will also be told what the spectacles are to be used for. The answers for question 1 and 2 maybe found in the back of this SW.

1. Frame = 48 - 22 4 1/2
PPD = 65/62
Distance spectacles
Dec =

2. Frame = 46 - 20 4 1/4
PPD = 63/60
Distance spectacles
Dec =

3. Frame = 44 - 20 4
PPD = 68/65
Reading spectacles
Dec =

4. Frame = 46 - 22 4 1/2
PPD = 66/63
Near spectacles
Dec =

5. Frame = 44 - 24 4 1/4
PPD = 70/66
Distance spectacles
Dec =

EXERCISE 23

Compute the distance, bifocal, and total decentration of each lens, in a pair of multifocal spectacles, necessary to eliminate prismatic effect. Answers to questions 1-4 may be found in the back of this SW.

1. Frame = 46 - 22 - 4 1/2
PPD = 69/66
Dist. dec =
Bifocal dec =
Total dec =

2. Frame = 46 - 26 - 4 3/4
PPD = 68/64
Dist. dec =
Bifocal dec =
Total dec =

3. Frame = 44 - 22 - 4 1/4
PPD = 68/65
Dist. dec =
Bifocal dec =
Total dec =

4. Frame = 44 - 20 - 4
PPD = 67/64
Dist. dec =
Bifocal dec =
Total dec =

5. Frame = 48 - 22 - 4 1/2
PPD = 72/68
Dist. dec =
Bifocal dec =
Total dec =

6. Frame = 48 - 26 - 4 1/2
PPD = 74/70
Dist. dec =
Bifocal dec =
Total dec =

7. Frame = 44 - 22 - 4
PPD = 67/64
Dist. dec =
Bifocal dec =
Total dec =

8. Frame = 50 - 20 - 4 1/2
PPD = 74/71
Dist. dec =
Bifocal dec =
Total dec =

EFFECTIVE POWER

During the last few pages, we investigated the effects of moving a lens laterally in front of the eye. We found that this displacement causes an induced prismatic effect which may or may not be desirable. We will now discuss the effects of moving a lens closer to or father away from the eye.

When administering a visual examination, the phoropter or refracting device is usually about 15 mm from the corneas; glasses prescribed from the examination may be only 12 mm from the eyes. Contact lenses may be on the corneas.

Lenses focus parallel light at a certain distance from the lens dependent, of course, upon their dioptric power. The doctor orders certain lenses in a certain position so that they will focus light on the retina.

Moving the prescribed lens closer to or farther away will move the focus as well. Because the light rays will have a different power, or effect on the eye, if the focus is moved we say that the EFFECTIVE POWER changes.

A PLUS LENS LOSES EFFECTIVE POWER AS IT IS MOVED CLOSER TO THE EYE, AND GAINS EFFECTIVE POWER AS IT IS MOVED AWAY. Therefore, we would have to increase the power of a plus (+) lens placed closer to the eye than the original.

A MINUS LENS, ON THE OTHER HAND, LOSES EFFECTIVE POWER AS IT IS MOVED AWAY. Therefore, we would have to decrease the power of a (-) lens placed closer to the eye than the original.

EXAMPLE: If a +5.00D lens is moved 10 mm toward the eye, an EQUIVALENT lens would be +5.27D. This lens would have the same effective power as the +5.00D lens 10 mm farther out.

You're probably asking how this was figured out. It could be figured out in wave power, but a much simpler method is using the formula below.

$$F(e) = \frac{F}{1 - dF}$$

Where F(e) is the equivalent power of the new lens, F is the power of the old lens and d is the distance moved in meters.

It is not required that you know how to figure the power of equivalent lenses, the doctor will do that, but you should know what happens to the power of lens when they are moved closer to, or farther away from, the eye.

ABERRATIONS IN LENSES

There are six inherent aberrations in ophthalmic lenses. These are:

1. Chromatic aberration
2. Spherical aberration
3. Coma
4. Marginal or oblique astigmatism
5. Curvature of field
6. Distortion

A discussion of each of these inherent lens faults will show which of them can be ignored by the lens designer and which ones must be taken into account when designing a specific lens.

Chromatic Aberration

Remember we said that prisms DISPERSE or break down light into its component colors. At the same time lenses act somewhat like prisms. These two statements may be combined, the result being - lenses disperse light, to some extent, due to their similarity to prisms. This dispersion of light by lenses is called CHROMATIC ABERRATION, and is illustrated below.

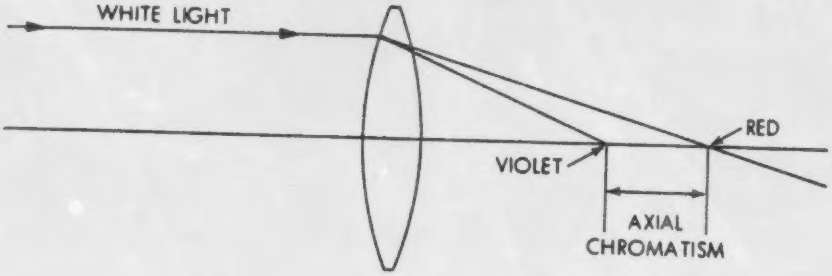


Figure 56

In ophthalmic corrections, except those of strong plus power of bifocals, this color aberration may be disregarded. Nature has provided a color sensitivity of the eye which aids in masking not only chromatic defects of the eye itself, but also small color defects in weak and moderate strength single vision lenses.

Spherical Aberration

We know that, figured out, a spherical lens should focus all parallel light rays at one single focus. In actual fact, this is not the case. Note in the diagram below that the rim rays are focusing before the paraxial rays, thus producing a blur instead of one single point focus

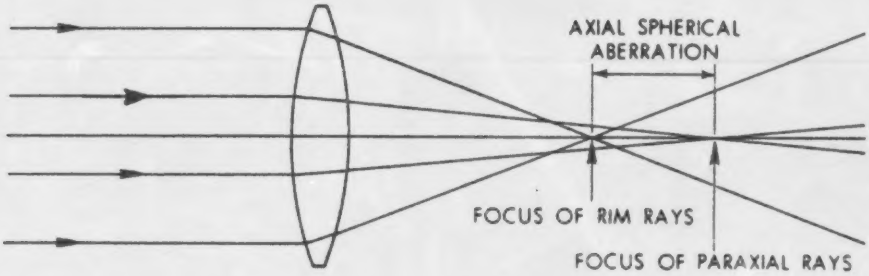


Figure 57

Ophthalmic lens designers do not have to worry about spherical aberration because the pupil of the eye limits the pencil of rays to a small area. This prevents the eye from seeing both rim and paraxial rays at the same time.

Coma

Comatic aberration is produced by parallel light striking a lens at an angle. The light rays bent first are focused first, the last rays refracted, focus last. This produces many foci as described in figure 58.

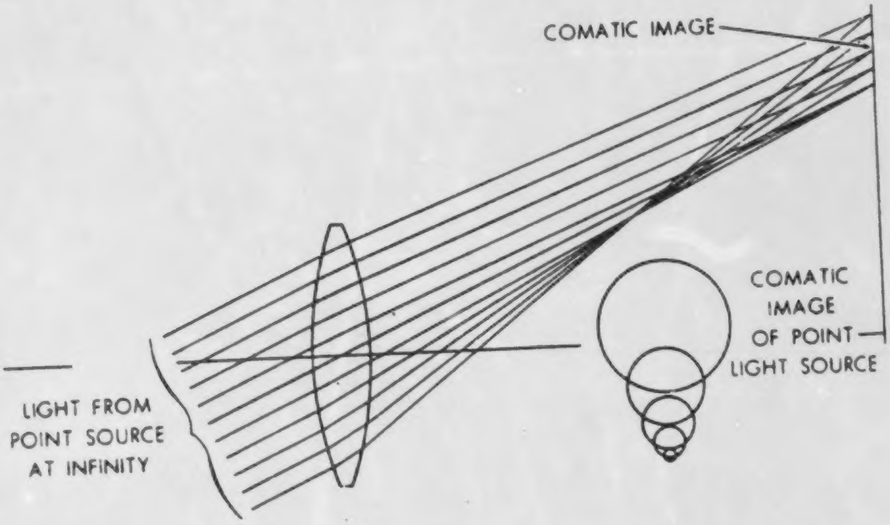

COMATIC IMAGE
COMATIC IMAGE OF POINT LIGHT SOURCE
LIGHT FROM POINT SOURCE AT INFINITY

Figure 58

Coma is a neglible aberration in ophthalmic lenses, again because the pupil only allows a thin pencil of light to enter the eye, thus eliminating the spread out focus.

Marginal (Oblique) Astigmatism

Marginal astigmatism is due to the fact that light rays striking a lens obliquely or at an angle are refracted differently in the vertical plane than the horizontal.

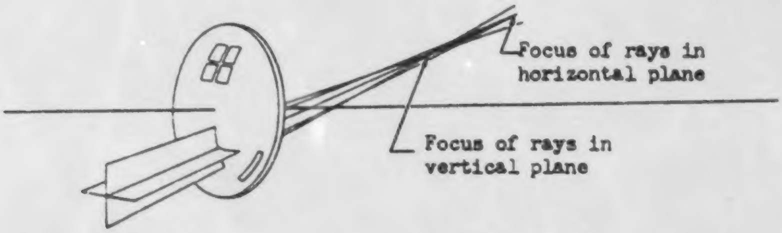
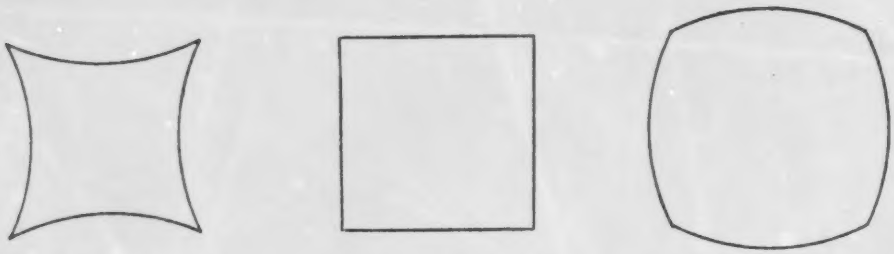

Focus of rays in horizontal plane
Focus of rays in vertical plane

Figure 59

By using the medium of altered lens curvatures, at the same time maintaining the lens power wanted, lens designers may eliminate this marginal astigmatism. The two image points, vertical and horizontal, may be brought together in one image point.

Distortion

Gradually increasing or decreasing magnification, encountered as the eye looks farther and farther from the lens center, produces DISTORTION. Excessive increase in deviation of a ray of light toward the lens margin accounts for this aberration. Uniform increases in the looking angle on the eye side makes a square appear like a pin-cushion with plus lenses and barrel shaped with minus lenses. See figure 60



PINCUSHION EFFECT
(Plus Lens)

NO DISTORTION

BARREL EFFECT
(Minus Lens)

Figure 60

Distortion cannot be eliminated in simple spectacle lenses, but in the average prescription, it is of no consequence and the critical observer can soon disregard the fault. Patients wearing strong convex, concave, or large prescription goggle lenses must resolutely determine to disregard the curved appearance of straight lines and the apparent motion of objects as the head is moved while fixation is maintained In a short time, experience will overcome appearances. Fortunately, distortion is reduced with the lens curvatures selected for marginal astigmatic correction.

Curvature of Field

By proper choice of lens curvatures for any closely associated range of power, marginal astigmatism is removed and one curved image surface is obtained. The image formed in the eye does not always coincide with the various positions of the eye. This is Far Point Sphere. This difference is the lens aberration known as CURVATURE OF FIELD.

Curvature of field is the variation of the image surface (retina) from a plane surface.

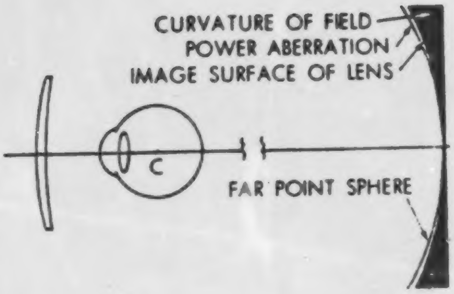


Figure 61

Translated, the discrepancy between the image field and far point sphere calls for small amounts of accommodation when looking obliquely through plus lenses, and a small amount of relaxation of accommodation through minus lenses. Since, at distance, the relaxed eye cannot further relax accommodation, some slight discrepancy in image quality for oblique looking directions results. The amount, however, is inconsequential compared to the advantages gained in image quality by marginal astigmatic correction.

To correct an ophthalmic lens for a minimum of marginal astigmatism and curvature of field, lens designers have varied the lens designs and curvatures and come up with the CORRECTED CURVE LENS.

A corrected curve lens compensates as much as possible for:

1. Marginal or oblique astigmatism
2. Curvature of field

OPHTHALMIC PRESCRIPTIONS

One of the duties you will perform as an optometry specialist involves the recording of spectacle prescriptions. You will also transfer prescriptions from various civilian forms to approved military forms. In order to perform this duty correctly, you must be able to recognize and correctly interpret the symbols used in spectacle prescriptions.

A complete ophthalmic prescription includes not only the lens formula, but the type and size of frame to be used, the placement of the lenses in the frame, and the type and tint of the lenses.

Customarily, the lens formula is written in the following order:

Sign of sphere
Power of shpere
Combination sign*
Sign of cylinder
Power of cyliner
Axis symbol
Axis orientation
Combination sign*
Power of prism
Position of base of prism

*Usually omitted

The power of the bifocal is listed below the above-mentioned data. Other characteristics, such as frame style and size, lens tint or treatment, bifocal type, thickness and base curve may also be listed. The interpupillary distance (PD) is also included.

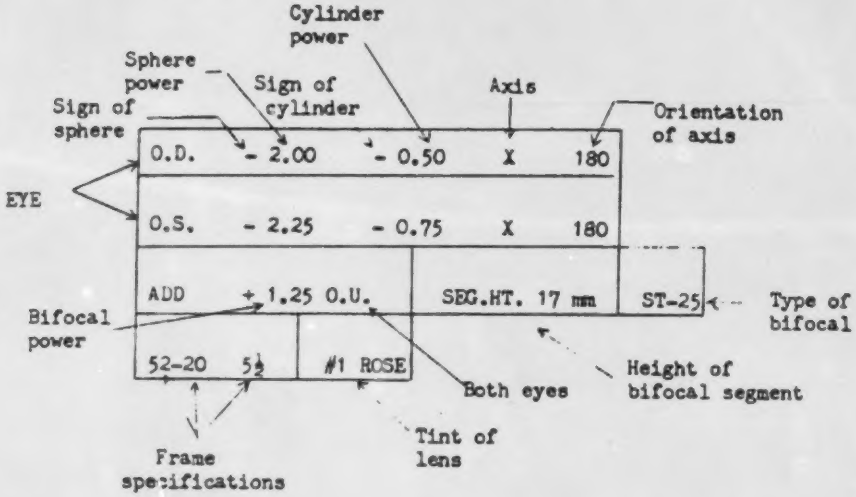

Cylinder power
Sphere power
Sign of cylinder
Axis
Sign of sphere
Orientation of axis
O.D. - 2.00 - 0.50 X 180
EYE
O.S. - 2.25 - 0.75 X 180
ADD + 1.25 O.U.
SEG.HT. 17 mm
ST-25
Type of bifocal
Bifocal power
52-20 5½
#1 ROSE
Both eyes
Height of bifocal segment
Tint of lens
Frame specifications

Figure 62

In order to save time and space on a prescription pad, many items are abbreviated as follows:

O.D.	Right eye
O.S.	Left eye
O.U.	Both eyes
+	Convex or convergent
-	Concave or divergent
$\overset{\frown}{\smile}$	Combination
D	Diopters
S, Sph	Sphere
C, Cyl	Cylinder
Pd or	Prism diopter
Ax or X	Axis
B	Base
Add	Reading addition
B.C.	Base Curve
PD	Interpupillary Distance
Dec	Decenter

TRANSPOSITION

In the last unit of instruction, you learned how to write an ophthalmic Rx (prescription). Ophthalmic Rx's are written in two major forms: MINUS CYLINDER or PLUS CYLINDER. The lens form is identified by the sign of the cylinder. THE SAME LENS FORMULA MAY BE WRITTEN IN EITHER PLUS OR MINUS CYLINDER WITHOUT CHANGING THE POWER OF THE LENS.

In the military the following rules must be observed:

1. ALL SINGLE VISION GLASS LENSES ARE ORDERED IN PLUS CYLINDER FORM.

2. ALL SINGLE VISION PLASTIC, PLASTIC MULTIFOCALS, AND GLASS MULTIFOCALS ARE ORDERED IN MINUS CYLINDER FORM.

The changing of a lens formula from one cylinder to another is called TRANSPOSITION.

EXAMPLE:

a. +1.00 - 2.00 x 180 (Minus Cylinder Form)

b. -1.00 + 2.00 x 090 (Plus Cylinder Form)

Lens formula A is equivalent to lens formula B. Both have the same foci and each has identical power. Formula A is written in minus cylinder form and formula B is written in plus cylinder form. To convert from one cylinder to another, we transpose the formula. There are two methods to convert between one cylinder form to another:

1. **Mathematical formula method**

2. Optical cross method

Mathematical formula method

The simplest method for converting between cylinder forms, and also the quickest is the mathematical method. There are three rules to be followed - MEMORIZE THEM. The importance cannot be stressed enough.

You will be transposing countless times every day in the clinic. The three steps are:

1. ALGEBRAICALLY ADD THE CYLINDER TO THE SPHERE AND RECORD AS THE NEW SPHERE.

2. CHANGE THE SIGN OF THE CYLINDER AND RECORD AS THE NEW CYLINDER.

3. CHANGE THE AXIS 90° AND RECORE AS THE NEW AXIS. (Remember - axes run from 001° to 180°. There is no axis greater than 180° and 000° is written as 180°.)

EXAMPLES:

1. +1.50 - 2.00 x 090 (minus cylinder)
Transposed
2. -0.50 + 2.00 x 180 (plus cylinder)

1. +1.25 + 1.00 x 035 (plus cylinder)
Transposed
2. +2.25 - 1.00 x 125 (minus cylinder)

1. -4.75 - 1.25 x 105 (minus cylinder)
Transposed
2. -6.00 + 1.25 x 015 (plus cylinder)

Note: The axis should be written with three (3) numbers; e.g., 180, 090, 007.

Optical Cross Method

You learned that spherocylinders have two major meridians 90° apart. Draw these meridians on a piece of paper, and label them according to axis given in the basic prescription.

EXAMPLE

+1.00 - 2.00 x 180
Transposed
-1.00 + 2.00 x 090

See figure 63 for the optical cross for the above Rx.

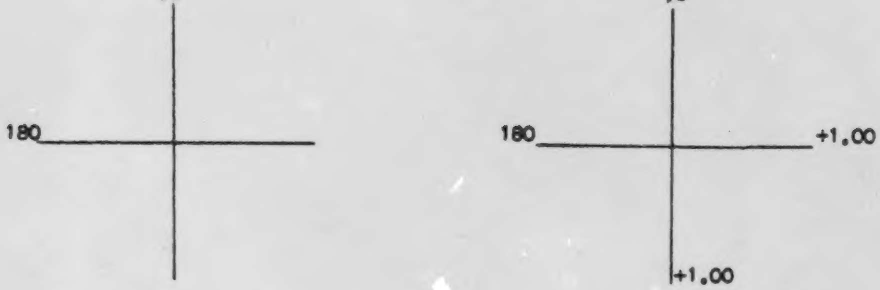


Figure 63

We know that the first element in the Rx is sphere power, meaning power in all meridians. We, therefore, place this number (+1.000 in this case) on both meridians. See figure 63 above.

The second element in the prescription is the cylinder power. In the Rx the axis is the axis of the cylinder but we know that the power of a cylinder is 90° away from the axis. Place the cylinder power on the diagram 90° from the axis. In this example, place -2.000 in the 090 meridian. Add algebraically.

The result on the diagram is -1.000 of power in the 090° meridian and +1.000 in the 180° meridian. Illustrated below.

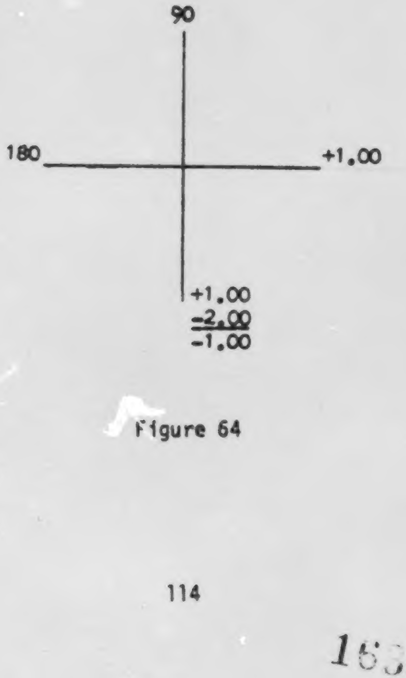


Figure 64

When we transpose to plus cylinder from optical cross, we assume the lowest power meridian to have the sphere power. In our example, we take -1.000 as the new sphere power. Then we figure out what power cylinder we need to add to the meridian 90° away to maintain the same power in that meridian. First let us take -1.000 as the sphere power.

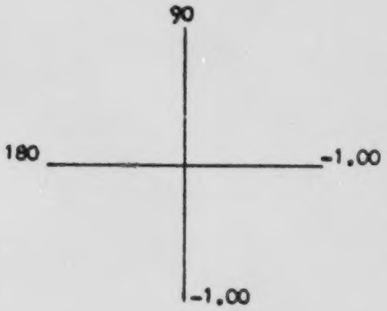


Figure 65

It works out that the power needed to maintain the +1.000 power in the 180 meridian is +2.000 added to the new -1.000 sphere, which would look like this:

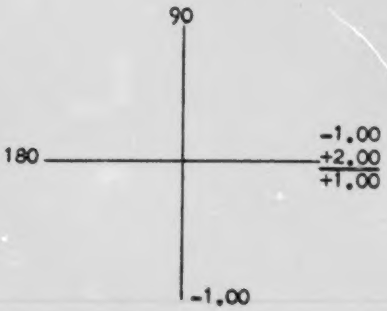
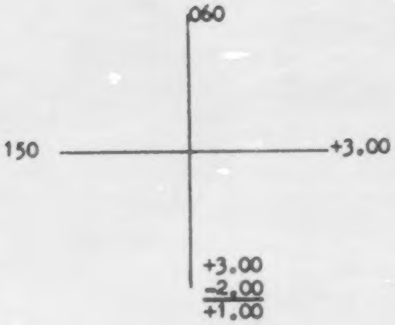


Figure 66

Now, though the cylinder power is in the 180th, we say that the axis will be 90° away or 090. This optical cross written down is the same as -1.00 + 2.00 x 090.

EXAMPLE

+3.00 - 2.00 x 150



Transposed: +1.00 +2.00 x 060

Figure 67

EXERCISE 24

Transpose the following Rxs to the opposite cylinder form. Answers to questions 1-8 may be found in the back of this SW.

1. +1.00 - 1.25 x 090

2. +2.25 + 2.00 x 180

3. -3.00 - 2.00 x 070

4. -3.25 + 2.25 x 160

5. +2.75 - 3.25 x 135

6. +1.25 + 3.00 x 172

7. -2.12 - 3.00 x 015

8. -2.25 + 3.75 x 045

9. +0.75 - 3.50 x 117

10. +0.50 + 0.50 x 132

11. -6.50 - 6.50 x 180

12. plano - 2.25 x 143

13. pl. + 1.50 x 078

14. +2.50 + 2.50 x 062

15. -3.37 + 1.50 x 014

16. +4.75 + 1.75 x 165

ABSORPTIVE LENSES

Today, sunglasses in prescription are attaining full recognition as a universal need. The additional comfort is interpreted as a basic requirement, not as an expensive luxury. The correction afforded by new glasses is of poor service if it cannot be enjoyed to its fullest advantage outdoors. Finally, it is obvious that "making do" with plano sunglasses is visually inadvisable and that the clip-on solution is an awkward one. The second pair, in outdoor prescription, is the only good solution to the problem. Growing acceptance of these judgements has brought on a "sunglass revolution."

Sunglasses were used in the 19th century but were not fully understood as to their glare protection characteristics. As a result, they were not made to uniform specifications.

During World War II, protective requirements for fliers produced a particularly fine green-yellow "anti-glare" glass, eventually marketed under the name "Ray-Ban." It was developed by Bausch & Lomb to meet requirements set down by the USAF.

The development of "Ray-Ban" glasses set scientists to research and give definitive explanations of the known benefits of outdoor filters. From their work, certain interesting ideas emerged:

First, to be most effective in bright sunlight, a sun glass should exclude not less than 80% of the whole light, and secondly, that the light should be excluded relatively evenly over the visible spectrum. The latter point ran exactly counter to the theory of the Ray-Ban green glasses, on the principle that truly color neutral glass would be especially important in a low transmittance filter. The low transmittance requirement, itself, was based on the need for protection against extreme reflected brilliance which, beyond causing visual discomfort, could impair vital dark-adaption.

There had always been the so-called "London Smokes" made by all the major companies; they had a gray appearance, but they were far from neutral. They gave the wearer a decidedly purplish and dusky view of things. Subjectively they could not hold a candle to the high quality green glass like Ray-Ban green. Air Force and Navy scientists sought a neutral glass that would eliminate color distortion and found that none would answer their specifications. A true neutral gray, one that would transmit all parts of the visible spectrum to the same degree, was unknown.

Starting with the basic Ray-Ban formula, Bausch & Lomb technologists worked their way through a long series of experimental batches. As they went, they flattened out the yellow green portion of the transmittance curve, without losing any of the desirable Ray-Ban properties in respect to clarity, physical stability, and absorptive capacity in the non-visible ends of the spectrum. Thus was born the Ray-Ban G-15 neutral gray. It was introduced in 1953 for plano sun glasses and in the next few years, was made available in molded blanks and uncuts for prescription use. A few small adjustments in the formula were made in later years to improve fusing and edging characteristics of bifocal prescriptions.

When offered to the general public, neutral gray glass had even greater success over a period of a decade than Ray-Ban green had experienced, and at this writing, has now outdistanced it in both plano and prescription forms.

The neutral gray lens as supplied by Army optical shops is called the N-15 lens. This means that the lens transmits 15% of the incident light. An N-31 lens is also available. Both of these lenses are usually restricted to flying goggles and aircrew members. The Ray-Ban type of lens may be available for qualified individuals in the standard plastic frame.

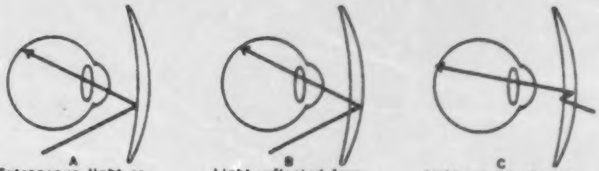
Lenses which absorb U.V. and I.R. without affecting visible light to a great extent are the Rose (pink) tints and the Therminion lens (pale green). The Rose lens is less effective in absorbing infrared than the Therminion.

"Shooters' glasses," those with a yellow tint, are named Kalichrome. They seem to increase visibility in haze due to their absorption of the blue end of the spectrum.

Clear-Coated Glasses

As you learned earlier, when light rays strike the surface of a lens or prism, a certain amount of light is lost by reflection and absorption. In an optical system with many elements, this loss could be quite considerable.

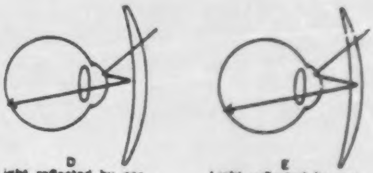
In a pair of glasses, the light loss at each surface is about 4% (mostly by reflection). Some of these reflections can be quite annoying when they are seen by the patient. T.V. and movie personalities also dislike the presence of reflection from their glasses as it distracts from their appearance. In some low light level situations, the 8% light loss may be significant to the patient. Below are some examples of spectacle reflection.



A
Extraneous light reflected from the rear lens surface into eye.

B
Light reflected from front lens surface into the eye.

C
Light entering the eye after double reflection within lens.



D
Light reflected by cornea to rear lens surface and back.

E
Light reflected by cornea to front lens surface and back.

Figure 68

Reflections can be reduced considerable by coating the surfaces of the spectacles with a substance which modifies the index of refraction of the glass-air surface. Usually lenses are coated with magnesium fluoride, the thickness being 1/4 wavelength of yellow light. They can very easily recognized by looking through them (at arm's length) onto a white background. They appear to have a smurky pattern as if gasoline had been dropped on them. Otherwise, they appear absolutely clear.

The interference pattern which is created by this coating allows more light to be transmitted through the lens. In the military, CCG or "clear coated glasses" are issued to flying personnel as night vision glasses. It should be noted here that it is the only approved night vision lens. Yellow lenses that are sold and advertised as "night vision lenses" actually decrease performance under low light levels.

TOUGHENED SAFETY LENSES

When someone speaks of a "heat-treated," "toughened," or "hardened" ophthalmic lens, he and his listeners usually think of the product in terms of the process it went through, or the surface impact it should withstand, or its end-use in safety glasses. There appear to be many vague conceptions of the toughened lens structure, but almost none of these provide knowledge adequate for an appreciation of the many factors on which impact resistance depends. This discussion is intended to dispel some of these misconceptions.

The toughening of glass, to increase its resitance to physical shock is not a 20th Century discovery. One of the first patents was taken out by Francois B.A.R. de la Bastie in 1874. He heated glass objects to a temperature near the softening point, then plunged them into a bath of substantially lower temperature. Other inventors followed quickly, altering the method of quench by use of metal molds, sand, steam, and compressed air. All these early men made one error in common - they believed that they were "hardening" the surface of the glass. The early workers were held back in development of processes by a lack of knowledge of the phenomena involved. Elimination of this drawback did not come for some 60 years after de la Bastie's disclosure.

Structure of a Toughened Lens

Generally one may say that a lens is broken when the surface is put in excessive tension. See figure 69 below.

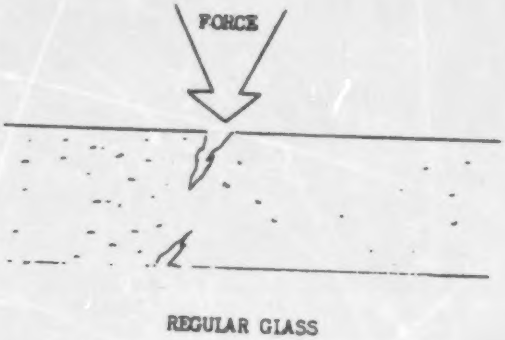


Figure 69

If by some treatment the surface is put in a state of compression, any shock or loading must first overcome the compression and then stress the piece to the limit of its strength in tension before breakage will occur. The process by which this is accomplished is known as reinforcing.

A toughened lens is a reinforced structure comparable to the familiar bicycle wheel. The "spokes," each placed in the right degree of tension, exert forces on the rim, keeping it in compression. If the spokes are tightened too far, they break. If the spokes are unevenly tightened, a useless warped wheel results.

The "spokes," by means of which a glass lens is toughened, are developed by expansion and rate of heat transfer. By heating the lens to the softening point of the glass, the lens is caused to expand the maximum amount without distortion. Then, by controlled chill, the surface volume is forced to shrink and become rigid while the inside is still malleable and can yield to the forces set up. However, as chill continues and heat is extracted from the inside, the glass becomes hard and unyielding. An internal tension results as cooling continues while the outside is maintained at a lower temperature.

Thus, when the lens reaches room temperature, the internal contraction must exert tension on the initially chilled and rigid surface volume. Being a single solid, the surface volume must resist this internal tension, and, in doing so, is compressed. The lens then is a toughened reinforced structure.

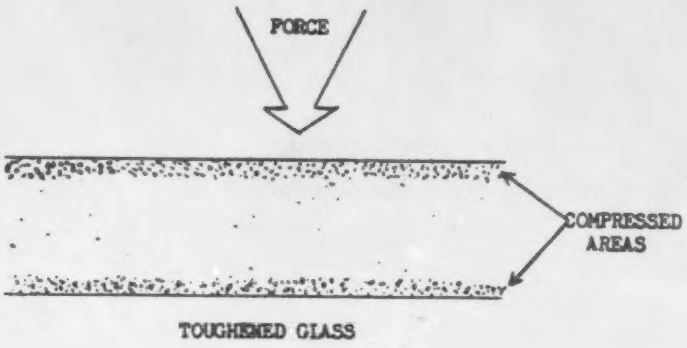


Figure 70

Impact and thermal shock strength of this reinforced structure is dependent on the thermal coefficient of expansion of the glass, the thermal conductivity, rate of chill and manner in which it is applied, size, shape, thickness, and surface quality of the glass. The importance of these items is not necessarily in the order named.

Importance of Surface Quality

Toughened lenses having a high C/T (compression/tension) ratio are characterized by having a relatively thinner skin of compressing at the surfaces than the compression skin of lenses with a low C/T ratio. So long as this compression layer is not abraded with fissures that vent into the internal tension zone, the lens will have high strength. Low strength or breakage can be expected with surface chips and scratches that break the compression surface envelope.

Badly scratched, chipped, or pitted safety lenses should, therefore, be replaced. If worn, they provide the wearer with a sense of security that may not exist.

Significance of Pattern

Appearance of a well-defined "cross" in a lens held in the plane polarized light of a polariscope (or colmascope, the two are synonymous) has been the basis of acceptance of the product as a toughened lens. The fact is that the cross-pattern, seen through the faces of the lens in the plane polarized light, shows only that the lens has been placed in some state of compression - tension balance, and that the quench was centered near the center of the cross pattern. The pattern does not necessarily disclose impact or thermal shock strength; however, the presence of a "cross" (called a MALTESE CROSS), when placed in plane polarized light, indicates the lens has been toughened.

Effect of Thickness

Curved lenses of good surface quality, of 2.2 mm thickness with normal tolerance, can be toughened to withstand impact of a 7/8" steel ball dropped 50 inches. In fact, many lenses of this thickness will withstand substantially greater blows.

Impact strength of toughened lenses tends to drop off rapidly with thickness of less than 2.2 mm. On the other hand, impact strength increases as lens thickness increases.

Chemically Treated Lenses

Recently, the servicing optical labs have been chemically treating some lenses to make them impact resistant. They do not have the characteristic "Maltese Cross" stress lines and nothing will show with examination through a colmascope because the lenses are not heat treated. The order form that returns with the spectacles will be stamped to indicate that the lenses are impact resistance.

Plastic Lenses

Another type of safety lens is the CR-39 or plastic lens (CR-39 is the code name of the plastic). CR-39 is a high-quality, hard and tough optical plastic which may soon be in exclusive use in military spectacles. Break resistance of plastic lenses is similar to that of heat-treated glass lenses, but susceptability to scratching is higher in the plastic lens. The major advantage of plastic lenses is that they are considerably lighter than glass lenses of equivalent powers.

High-Power Lenses

As you remember, minus lenses are thicker at the periphery than at the center, and plus lenses are thicker at the center than at the periphery. In very high powers, this thickness becomes excessive; as the lens weight increases the cosmetic effects (looks) are poor, and mounting in a frame may be difficult. In order to reduce some of these objections, LENTICULAR LENSES are prescribed. A lenticular lens consists of a button, which has the correct Rx, ground onto a flat carrier lens. Lenticulars may be either plus power, as in a cataract case (patient has had his lens removed), or minus power (myodisc). A disadvantage of the lenticular lens is that the field of view is extremely restricted.

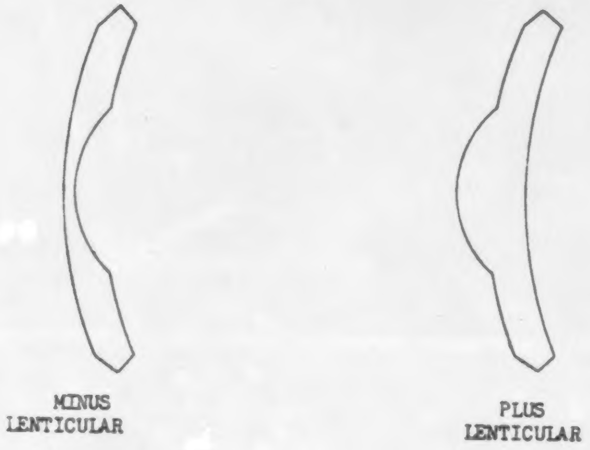


Figure 71

PROFESSIONAL AND PATIENT RELATIONSHIPS

OBJECTIVES

The purpose of this study guide and workbook is to depict to you

1. Professional relations
2. Patient relations
3. Professional standards of conduct

INTRODUCTION

You are going to be placed in a position where you will be providing a service to many individuals. Your knowledge and proper application of the concepts of professional and patient relations will give greater patient satisfaction, a smoother running clinic, and increased personal satisfaction.

INFORMATION

PROFESSIONAL RELATIONS

In your clinic, good professional relations must be maintained because the medical profession is a team effort made up of many specialties, both of professional and allied medical personnel. In the performance of your duties, it will be required at times that you refer patients to many different departments. So you will be working closely with other medical personnel in your clinic and other clinics throughout the hospital to which you are assigned. It is absolutely necessary to maintain professional relationships with these persons during duty hours.

PATIENT RELATIONS

You must be aware that in the operation of your clinic, you are performing a service to which each of your patients is entitled. This service should be the best that you and your clinic are able to render. Do not at any time feel, or show the feeling, that you are doing the patient a favor by just being there. Make sure you are congenial and courteous to each patient. At times you will find this very hard to do, but as a part of a professional team, you will find it very necessary.

It is extremely important that you be concerned for the needs of the patient, including psychological as well as optometric needs. A patient doesn't know what will happen to them in an optometry clinic and they may need some reassurance. A relaxed patient will give more accurate results than a nervous and worried individual.

Give the patient clear instructions, whether it is directions to another department or instructions for performing a procedure or test in the clinic. They are strangers in a strange environment and a pleasant and competent handling of their case will really set the patient at ease.

There will be many visitors to your clinic and it is your responsibility as the person whom the public sees, as the representative of the USAF and the optometric profession, to conduct yourself in a friendly and courteous manner. Also, be able to answer most reasonable questions about your clinic and the USAF.

The general public at times will require your services in the performance of visual screenings at the public schools around your base. The manner in which you conduct yourself during these screenings will be that upon which the general public will base their opinion of the USAF, military medicine, and the optometric profession. You're going to have to be very expert in doing your job as an optometric technician.

PROFESSIONAL STANDARDS OF CONDUCT

At no time are you at liberty to discuss anything that pertains to a patient or his medical record unless it is with an authorized person with a need to know. Anything a patient tells you must be held in strictest confidence or the patient will lose faith in your clinic and Air Force Medicine in general.

Some good rules to remember are

1. In all of your professional contacts you should be honest and loyal and serve to the best of your ability.

2. Hold in strictest confidence the details of professional service rendered by your doctor.

3. Do not provide any service that you are not specially trained and authorized to perform (as outlined in STS).

4. Make no derogatory remarks which would imply that any doctor had not provided the best treatment possible for the patients.

5. Make no derogatory remarks about the profession of Optometry.

6. Realize your obligation to continue your education and avail yourself of all educational opportunities to increase the level of your skills.

7. Make every attempt to attend educational seminars provided by the Optometric Profession.

EXERCISE 25

Answer the following questions in the spaces provided.

1. Give two examples of why good professional relations are necessary in the military hospital environment.

2. What is meant by the term "patient needs?"

3. Why should a patient's medical condition or history be held in the strictest confidence?

APPENDIX I - ANSWERS TO EXERCISES

EXERCISE 3

1. 0.038
2. 0.00085
3. 1.56
4. 0.00001

EXERCISE 4

1. 0.25
2. 0.875
3. 0.75

EXERCISE 5

1. $x = 4$
2. $x = 5$
3. $y = 3$

EXERCISE 6

1. $x = 25$
2. $x = 37.33$

EXERCISE 7

1a. 450

1b. 0.045

2a. $4.2 \times 10^{+5}$

2b. 2.931×10^{-3}

3a. $2.268 \times 10^{+9}$

3b. 1.50×10^{-6}

4a. $1.30 \times 10^{+4}$

4b. 9.10×10^{-1}

EXERCISE 8

1. $4.2 \times 10^{+3}$ cm
2. 5.0×10^{-1} m
3. 8.2×10^{-2} mm
4. $3.57 \times 10^{+5}$ mm

EXERCISE 13

1. 5.00 D
2. 4.00 D
3. 0.50 D
4. 5.00 D
5. 2.50 D

11. 44.44 cm
12. 80.00 in
13. 400 mm
14. 0.30 m
15. 10 cm

EXERCISE 14

1. +2.75 D
2. -1.75 D

EXERCISE 15

1. +7.00 D
2. -1.00 D

EXERCISE 18

8a. -4.25 D sphere

8b. +4.75 D sphere

8c. +2.50 D sphere

EXERCISE 20

1. 1.00$^\Delta$ BO
2. 1.40$^\Delta$ BO
3. 3.15$^\Delta$ BO

EXERCISE 21

1. 0.50$^\Delta$ BIOD, 0.50$^\Delta$ BIOS
2. 0.64$^\Delta$ BIOD, 0.71$^\Delta$ BIOS
3. 0.80$^\Delta$ BOOD, 1.00$^\Delta$ BOOS

EXERCISE 22

1. 2 1/2 in
2. 1 1/2 in
3. 1/2 out

EXERCISE 23

1. Dist. dec.= 1/2 out
   Bifocal dec.= 1 1/2 in
   Total dec.= 1 in
2. Dist. dec. = 2 in
   Bifocal dec. = 2 in
   Total dec. = 4 in
3. Dist. dec. = 1 out
   Bifocal dec. = 1 1/2 in
   Total dec. = 1/2 in
4. Dist. dec. = 1 1/2 out
   Bifocal dec. = 1 1/2 in
   Total dec. = 0

EXERCISE 24

1. -0.25 + 1.25 x 180
2. +4.25 - 2.00 x 090
3. -5.00 + 2.00 x 160
4. -1.00 - 2.25 x 070
5. -0.50 + 3.25 x 045
6. +4.25 - 3.00 x 082
7. -5.12 + 3.00 x 105
8. +1.50 - 3.75 x 135

APPENDIX II - GLOSSARY OF TERMS

ABSORPTION - the process in which radiant energy is converted into another energy form - usually heat.

AMPLITUDE - the maximum displacement of a wave form.

ANALYZER - a calibrated polarizer used to determine the plane of polarized light.

A.O.A.R. - the American Optometric Association Registry.

BASE CURVE - the fixed curve of a lens, usually ground on at the factory.

BIFOCAL - a lens having two focal lengths (as opposed to a single vision lens which has one focal length).

BIFOCAL DECENTRATION - the amount the bifocal O.C. is displaced from the distance O.C. It is figured by comparing distance PD to near PD.

BINOCULAR - pertaining to both eyes.

CLEAR COATED GLASS (CCG) - a lens coated with magnesium fluoride to reduce reflections.

COLMASCOPE - an instrument for determining whether or not a lens has been heat treated.

COMPOUND - spherocylindrical or toric.

CONCAVE - a surface that curves inward.

CONTACT LENS - a lens placed directly upon the cornea.

CONVERGENCE - the coming together of light rays.

CONVEX - curved outwards.

CORRECTED CURVE LENS - a lens that compensates for marginal astigmatism and curvature of field.

CYCLE - one complete wave form.

CYLINDER - a lens component with a meridian of zero power and a meridian of maximum power 90° away.

DECENTRATION - the moving around of the O.C. of a lens with respect to the geometric center of the frame so as to eliminate or induce prismatic effect.

DEVIATION - the change in direction of a light ray after passing through a prism.

DIFFUSION - the scattering of light.

DIOPTRICS - that branch of optics which deals with lenses and their effects on light.

DIPLOPIA - double vision.

DISPERSION - the breaking down of white light into its component colors.

DISTANCE DECENTRATION - the alignment of the distance O.C.s of a lens with the patient's distance PD.

DISTORTION - the defect in a lens that causes a straight line to appear curved.

DIVERGENCE - the spreading apart of light rays.

EFFECTIVE POWER - the effect of a lens upon the eye when it is moved from one distance before the eye to another.

EQUIVALENT POWER - the power prescribed for a lens that has a different distance from the eye than the test lens but which has the same effect on the eye as the test lens had at the test distance.

FOCAL LENGTH - the distance between the focus of a lens and the optical center of the lens.

FOCUS - that point where light rays (or their geometric extensions) meet.

FRAME PD - the eye size plus the bridge size.

FREQUENCY - the number of wave forms (cycles) passing a reference point in a given amount of time.

GEOMETRIC CENTER - the physical center of a lens or frame.

IMAGE - the representation of an object formed by the intersection of light rays.

INDEX OF REFRACTION - a measure of the optical density of a transparent medium.

INFRARED - light waves beyond the red portion of the visible spectrum. They have longer wavelengths than visible light.

INTERPUPILLARY DISTANCE (PD) - the distance between the centers of a person's pupils.

KALICHROME - a yellow shooter's glass that reduces the effects of haze.

LENS MEASURE - an instrument that measures surface curvature and gives this curvature in diopters.

LENTICULAR LENSES - ophthalmic lenses of high dioptric power with the prescription ground only in the central portion, the periphery is usually plano and serves as a carrier so that the lens is suitable for spectacles.

LIGHT - that which we see by.

MAGNIFICATION - an increase in the apparent or perceived size of an object.

MALTESE CROSS - a pattern seen through a colmascope indicating a heat treated lens.

MERIDIAN - an imaginary line extending across a lens through its geometrical or optical center.

MINIFICATION - a decrease in the apparent or perceived size of an object.

MONOCHROMATIC - light of one color.

MONOCULAR - pertaining to one eye.

MULTIFOCAL - a lens with two or more focal lengths due to additional segments ground or fused into the main carrier lens. Examples: bifocal, trifocal, etc.

MYODISC - a minus lenticular lens.

N-15 - a neutral gray absorptive lens of 15% light transmission.

N-31 - a neutral gray absorptive lens of 31% light transmission.

NASAL - toward the nose.

NEAR DECENTRATION - the alignment of the near O.C.s of a lens with the patient's near PD.

NORMAL - an imaginary reference line drawn perpendicular to a lens or mirror surface at the points where light rays strike.

OBJECT - the source of light rays in an optical diagram.

OPTICAL CENTER - that point on a lens through which light passes without deviation.

OPTICIAN- dispenses or fabricates spectacles.

OPHTHALMOLOGIST - an M.D. who has taken a residency in diseases and surgery of the eye.

OPTOMETRIST (O.D.) - has at least 6 years of college. He is primarily concerned with the problems of vision and the correction of defects of vision.

PARALLELISM - the situation where light rays are neither converging nor diverging.

PHOTON - a "packet" of light energy.

PLANO - flat, having no power.

POLARIZATION - the limiting of light transmission to one major meridian.

PRISM - an optical element whose surfaces are flat and two of which are not parallel.

PRISM DIOPTER - a measure of the deviating power of a prism.

PRISMATIC EFFECT - the ability of ophthalmic lenses to act like prisms.

RAY-BAN - a dark green absorptive lens.

REAL FOCI - the foci produced by the actual intersection of light rays.

REFLECTION - the throwing back of light incident upon a surface.

REFRACTION - the change in direction of light as it passes obliquely from one medium to another of different optical density.

ROSE TINT - a pink tint that absorbs in the infrared and ultraviolet.

SINGLE VISION - a lens with one focal length.

SPHERE - a lens with one point focus.

SPHERICAL EQUIVALENT - a spherical lens whose focal point coincides with the circle of least confusion of a given spherocylindrical lens. It is arrived at mathematically by algebraically adding 1/2 the cylinder power to the sphere.

SPHEROCYLINDER - a lens integrating both sphere and cylinder power.

SURFACE CURVATURE - one of the two primary factors influencing lens power.

TEMPORAL - towards the temple.

THERMINON - a light greenish-blue tinted lens that absorbs in the infrared and ultraviolet with little absorption in the visible.

TORIC - compound or spherocylindrical.

TOTAL DECENTRATION - the total amount that each of the bifocal O.C.s must be moved in order to correspond to the lines of sight in the near position.

TRANSPOSITION - the mathematical conversion from one cylinder form to another.

TRIFOCAL - a lens with three primary points of focus or focal lengths.

VIRTUAL FOCI - foci that do not actually exist. In optical diagrams they are composed of geometric extensions of light rays.

VISUAL ACUITY - acuteness, clearness or sharpness of vision.

WAVELENGTH - that distance from any point on a wave form to the same point on an adjacent wave form.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson ; 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3 ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE The Bony Orbit

LESSON DURATION

CLASSROOM /Laboratory 1 hr/0 hrs	Complementary 0.2 hrs	TOTAL 1.2 hr

POI REFERENCE

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SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	1 Sep 75		
	13 Jan 76		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW 3ABR91235-II-1 Slide Set, "Anatomy and Physiology of the Visual System"

CRITERION OBJECTIVES AND TEACHING STEPS

II-1b. Identify anatomical landmarks of the bony orbit.

(Teaching steps are listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE The Ocular Tunics

LESSON DURATION

CLASSROOM /Laboratory 3 hrs/0 hrs	Complementary 0.6 hr	TOTAL 3.6 hrs

POI REFERENCE

PAGE NUMBER 7	PAGE DATE 25 June 1975	PARAGRAPH 1c

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	8 Sep 75		
	13 Jan 76		
	9 Feb 76		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Eye Model (12)	NA	NA	SW 3ABR91235-II-1 Fundamentals for the Optometric Assistant Slide Set, "Anatomy and Physiology of the Visual System" FLC 7-82

CRITERION OBJECTIVES AND TEACHING STEPS

II-1c. Describe the anatomy and physiology of the ocular tunics.

(Teaching steps are listed in Part II) 182

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 197	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
The Extrinsic Ocular Muscles

LESSON DURATION

CLASSROOM/Laboratory 2 hrs/0 hrs	Complementary 0.4 hrs	TOTAL 2.4 hrs

POI REFERENCE

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SUPERVISOR APPROVAL

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	8 Sep 75		
	13 Jan 76		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW 3ABR91235-II-1

CRITERION OBJECTIVES AND TEACHING STEPS

II-1d. Describe the anatomy and physiology of the extrinsic ocular muscles.

(Teaching steps are listed in Part II)

ATC FORM AUG 73 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE Ocular Motility

LESSON DURATION

CLASSROOM/Laboratory 5 hrs/0 hrs	Complementary 0.4 hrs	TOTAL 5.4 hrs

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Strabismus Cover Test Demonstrator(12)	NA	NA	SW 3ABR91235-II-1

CRITERION OBJECTIVES AND TEACHING STEPS

II-1e. Explain ocular motility.

(Teaching steps are listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Ocular Motility - Instruments and Procedures

LESSON DURATION

CLASSROOM/Laboratory	Complementary	TOTAL
1 hr/0 hrs	1.0 hrs	2 hr

POI REFERENCE

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Red Lens Test (12) Prince Rule (6) VTA-ND (6) Keystone Skills Unit (4) Worth 4-Dot Test (6) Occuluders (2) Penlights (4)	NA	NA	SW 3ABR91235-II-1 Keystone Visual Skills Charts

CRITERION OBJECTIVES AND TEACHING STEPS

II-1f. Describe instrumentation and procedures used in detecting and measuring anomalies of ocular motility.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Ocular Motility - Determination of Anomalies

LESSON DURATION

CLASSROOM/Laboratory 3 hrs/7 hrs	Complementary 3.0 hrs	TOTAL 13 hrs

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Red Lens Test (12) Prince Rule (6) VTA-ND (6) Keystone Skills Unit (4) Worth 4-Dot Test (6) Occluders (2) Penlights (4)	NA	NA	SW 3ABR91235-II-1 CDM-117 Keystone Visual Skills Charts

CRITERION OBJECTIVES AND TEACHING STEPS

II-1g. Using a student as a patient, and given the necessary instruments, equipment and forms, correctly determine the presence or absence of monocular or binocular anomalies of ocular motility.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SE[illegible]	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE The Ocular Media

LESSON DURATION

CLASSROOM/Laboratory 1 hr/0 hrs	Complementary 0.5 hrs	TOTAL 1.5 hr

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW 3ABR91235-II-1 Elements of Optics Fundamentals for the Optometric Assistant

CRITERION OBJECTIVES AND TEACHING STEPS

II-1h. Describe the anatomy and physiology of the ocular media.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP [illegible]	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Nervous System of the Eye and Adnexa

LESSON DURATION

CLASSROOM /Laboratory 1 hr/0 hrs	Complementary 0.5 hrs	TOTAL 1.5 hr

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR91235-II-1

CRITERION OBJECTIVES AND TEACHING STEPS

II-1i. Describe the nervous system divisions which innervate the eye and adnexa.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Ophthalmodiagnostic Drugs

LESSON DURATION

CLASSROOM /Laboratory 2 hrs/0 hrs	Complementary 1.0 hrs	TOTAL 3 hrs

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR91235-II-1

CRITERION OBJECTIVES AND TEACHING STEPS

II-1j. Explain actions and uses of ophthalmodiagnostic drugs.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 5	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Ophthalmic Topical Anesthetics

LESSON DURATION

CLASSROOM/Laboratory 1 hr/0 hrs	Complementary 0.5 hrs	TOTAL 1.5 hr

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR91235-II-1

CRITERION OBJECTIVES AND TEACHING STEPS

II-1k. Explain selection and use of ophthalmic topical anesthetics.

(Teaching steps are listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Prevention, Recognition and Disposition of Drug Reactions

LESSON DURATION

CLASSROOM /Laboratory .5 hr/0 hrs	Complementary 0.25 hrs	TOTAL 0.75 hr

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR 91235-II-1

CRITERION OBJECTIVES AND TEACHING STEPS

II-11. Describe prevention, recognition and disposition of drug reaction cases.

(Teaching steps are listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Instillation of Ophthalmic Drops

LESSON DURATION

CLASSROOM/Laboratory	Complementary	TOTAL
.5 hr/0 hrs	0.25 hrs	0.75 hr

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR91235-II-1

CRITERION OBJECTIVES AND TEACHING STEPS

II-1m. Describe accepted and safe procedures for instillation of ophthalmic drops.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Intraocular Pressure Measurement

LESSON DURATION

CLASSROOM/Laboratory	Complementary	TOTAL
3 hrs/6 hrs	20 hrs	11 hrs

POI REFERENCE

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	12 Jan 76		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Corneal Anesthetic (12) Tonometer (6)	NA	NA	SW3ABR91235-II-1 Videotape: "Tonometry" CDM-20

CRITERION OBJECTIVES AND TEACHING STEPS

II-1n. Using a student as a patient, and given the necessary equipment and supplies, correctly administer an intraocular pressure measurement test without injury to the patient.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
The Visual Pathway

LESSON DURATION

CLASSROOM/Laboratory	Complementary	TOTAL
3 hrs/0 hrs	1.5 hrs	4.5 hrs

POI REFERENCE

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW3ABR91235-II-1

CRITERION OBJECTIVES AND TEACHING STEPS

II-1o. Describe the anatomy and physiology of the visual pathway.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 12 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Pupillary Reflexes

LESSON DURATION

CLASSROOM/Laboratory 1 hr/1 hr	Complementary 1.0 hrs	TOTAL 3 hrs

POI REFERENCE

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Occluders (2) Penlights (4)	NA	NA	SW3ABR91235-II-1 SF 88 DD 741

CRITERION OBJECTIVES AND TEACHING STEPS

II-1p. Using a student as a patient, and given the necessary instruments, correctly administer tests to determine the presence or absence of various pupillary reflexes.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP [illegible]	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
The Visual Fields

LESSON DURATION

CLASSROOM/Laboratory 2 hrs/12 hrs	Complementary 6.5 hrs	TOTAL 20.5 hrs.

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	1 Sep 76		
	13 Jan 76		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Perimeter (6) Tachistoscope (6) Tangent Screen (12) Autoplot (12)	NA	NA	SW3ABR91235-II-1 Visual Field Charts, peripheral Visual Field Charts, central Autoplot charts Harrington-Flocks Tachistoscope charts WS3ABR91235-II-1r

CRITERION OBJECTIVES AND TEACHING STEPS

II-1q. Using a student as a patient, and given the necessary instruments and forms, correctly measure and record the extent of the peripheral visual field to within ± 10 degrees.

II-1r. Using a student as a patient, and given the necessary instruments and forms, correctly locate and record central visual field defects with a positional accuracy of ± 5 degrees.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 12 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Visual Acuity

LESSON DURATION

CLASSROOM/Laboratory 2 hrs/0 hrs	Complementary 0.5 hrs	TOTAL 2.5 hrs

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW 3ABR91235-II-3 Slide Set: "Eye As An Optical Instrument"

CRITERION OBJECTIVES AND TEACHING STEPS

II-3a. Describe types of visual acuity.

(Teaching steps are listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System
LESSON TITLE Ametropia	

LESSON DURATION

CLASSROOM/Laboratory 4 hrs/0 hrs	Complementary 0.75 hrs	TOTAL 4.75 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
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SIGNATURE	DATE	SIGNATURE	DATE
	1 Sep 75		
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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW 3ABR91235-II-3 Elements of Optics Fundamentals for the Optometric Assistant Slide Set: "Eye as an Optical Instrument"

CRITERION OBJECTIVES AND TEACHING STEPS

II-3b. Define types of ametropia.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Measuring and Recording Visual Acuity

LESSON DURATION

CLASSROOM/Laboratory 3 hrs/1.5 hrs	Complementary 0.75 hrs	TOTAL 5.25 hrs

POI REFERENCE

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Snellen Wall Chart(12) Snellen Near Point Chart (12) Projecto Chart (6) VTA-ND (6) Keystone Skills Unit (4)	NA	NA	SW 3ABR91235-II-3 DD Form 741 SF 88 Keystone Visual Skills Charts

CRITERION OBJECTIVES AND TEACHING STEPS

II-3c. Using students as patients, and given the necessary equipment and forms, correctly measure and record the clinical visual acuity of each patient within standards described in AFM 160-17.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Screening for Amblyopia or Ametropia

LESSON DURATION

CLASSROOM /Laboratory 0/2.5 hrs	Complementary 0 hrs	TOTAL 2.5 hrs

POI REFERENCE

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PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Snellen Wall Chart (12) Projecto Chart (6) VTA-ND (6) Pinhole Test (12) Plus Lens Test (12)	NA	NA	SW 3ABR91235-II-3 DD Form 741 SF 88

CRITERION OBJECTIVES AND TEACHING STEPS

II-3d. Using a student as a patient, and given the necessary equipment and forms, correctly administer and record visual screening tests designed to detect amblyopia and/or ametropia.

(Teaching steps are listed in Part II)

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson [illegible]	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Amplitude of Accommodation and Presbyopia

LESSON DURATION

CLASSROOM /Laboratory 2 hrs/0 hrs	Complementary 0.75 hrs	TOTAL 2.75 hrs

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	13 Sep 76		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	3ABR91235-II-3 MN9480

CRITERION OBJECTIVES AND TEACHING STEPS

II-3e. Explain the relationship between amplitude of accommodation and presbyopia.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Measure and Record Amplitude of Accommodation

LESSON DURATION

CLASSROOM/Laboratory 0 hrs/1 hrs	Complementary 0.25 hrs	TOTAL 1.25 hr

POI REFERENCE

PAGE NUMBER 10	PAGE DATE 25 June 1975	PARAGRAPH 3f

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	8 Sep 75		
	13 Sep 76		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Prince Rule (6)	NA	NA	SW 3ABR91235-II-3 SF 88

CRITERION OBJECTIVES AND TEACHING STEPS

II-3f. Using a student as a patient and given a Prince Rule, correctly measure and record the amplitude of accommodation of the patient to the standards described in AFM 160-17.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE Cues of Depth Perception

LESSON DURATION

CLASSROOM /Laboratory 1 hr/0 hrs	0.25 Complementary hrs	TOTAL 1.25 hr

POI REFERENCE

PAGE NUMBER 11	PAGE DATE 25 June 1975	PARAGRAPH 3g

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	5 Sep 75		
	13 Sep 76		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW 3ABR91235-II-3

CRITERION OBJECTIVES AND TEACHING STEPS

II-3g. Describe the cues of depth perception.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE Determining Clinical Depth Perception

LESSON DURATION

CLASSROOM/Laboratory 1 hr/4.5 hrs	Complementary 1 hrs	TOTAL 6.5 hrs

POI REFERENCE

PAGE NUMBER 11	PAGE DATE 25 June 1975	PARAGRAPH 3 h

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	8 Sep 75		
	13 Sep 75		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Verhoeff stereoptor (6) Stereofly (6) VTA-ND (6) Keystone Skills Unit (4)	NA	NA	SW 3ABR91235-II-3 SF 88 Keystone Visual Skills Charts

CRITERION OBJECTIVES AND TEACHING STEPS

II-3h. Using a student as a patient, and given the necessary equipment and forms, accurately determine and record the presence or absence of clinical depth perception (stereopsis).

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDC Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Characteristics and Anomalies of Color Vision

LESSON DURATION

CLASSROOM/Laboratory	Complementary	TOTAL
1.5 hrs/0 hrs	0.25 hr	1.75 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
11	25 June 1975	3i

STS/CTS REFERENCE

NUMBER	DATE
STS 912X5	3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	8 Sep 75		
	13 Jan 76		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW 3ABR91235-II-3

CRITERION OBJECTIVES AND TEACHING STEPS

II-3i. Describe characteristics and anomalies of color vision.

(Teaching steps are listed in Part II)

ATC FORM 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE SSDB Wilson 2 SEP 1975	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE Color Vision Testing

LESSON DURATION

CLASSROOM/Laboratory 1.5 hrs/3.5 hrs	Complementary 0.75 hrs	TOTAL 5.75 hrs

POI REFERENCE

PAGE NUMBER 11	PAGE DATE 25 June 1975	PARAGRAPH 3 j

STS/CTS REFERENCE

NUMBER STS 912X5	DATE 3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	8 Sep 75		
	13 Jan 76		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
Keystone Skills Unit (4) Pseudoisochromatic plates (6) USAF Color Threshold Tester (12) Farnsworth Lantern (12)	NA	NA	SW 3ABR91235-II-3 DD Form 741 SF 88 Keystone Visual Skills Charts Color Threshold Score Sheets

CRITERION OBJECTIVES AND TEACHING STEPS

II-3j. Using a student as a patient, and given the necessary instruments and forms, correctly administer and record the results of color vision testing to the standards described in AFM 160-17.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE MSDB Wilson 2 SEP 197	INSTRUCTOR
COURSE NUMBER 3ABR91235	COURSE TITLE Optometry Specialist
BLOCK NUMBER II	BLOCK TITLE The Visual System

LESSON TITLE
Ocular Emergencies and First Aid

LESSON DURATION

CLASSROOM/Laboratory	Complementary	TOTAL
4 hrs/0 hrs	2 hr	6 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
12	25 June 1975	4

STS/CTS REFERENCE

NUMBER	DATE
STS 912X5	3 March 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE
	8 Sep 75		
	13 Jan 76		

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
NA	NA	NA	SW 3ABR91235-II-4 Slide Set, "Ocular Emergencies"

CRITERION OBJECTIVES AND TEACHING STEPS

II-4a. Explain emergency/first aid treatment techniques in ocular trauma.

(Teaching steps are listed in Part II)

ATC FORM AUG 72 770

STUDY GUIDE AND WORKBOOK

3ABR91235-II

Technical Training

Optometry Specialist Course

BLOCK II

THE VISUAL SYSTEM

October 1975

10-7

SCHOOL OF HEALTH CARE SCIENCES, USAF
Department of Biomedical Sciences
Sheppard Air Force Base, Texas 76311

Designed For ATC Course Use

DO NOT USE ON THE JOB

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This supersedes SW 3ABR91235-II, August 1974

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Department of Biomedical Sciences
School of Health Care Sciences, USAF
Sheppard Air Force Base, Texas 76311

SW 3ABR91235-II-1
October 1974

ANATOMY AND PHYSIOLOGY OF THE VISUAL SYSTEM

OBJECTIVES

This Study Guide and Workbook is designed to give you basic knowledge in the following areas:

1. The ocular adnexa
2. The bony orbit
3. The ocular tunics
4. The extrinsic ocular muscles
5. Ocular motility
6. Instrumentation and procedures used to detect and measure anomalies of ocular motility
7. The ocular media
8. Nervous system divisions of the eye and adnexa
9. Actions and uses of ophthalmodiagnostic drugs
10. Ophthalmic topical anesthetics
11. Prevention, recognition, and disposition of drug reactions
12. Instillation of ophthalmic drops
13. Intraocular pressure measurement
14. The visual pathway
15. Pupillary reflexes
16. The visual field
17. Peripheral visual field methods
18. Central visual field methods

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INFORMATION

THE OCULAR ADNEXA

There are several structures or appendages of the eye that are classified as ocular adnexa. The adnexa can be divided into five groups:

1. Eyelids
2. Eyebrows
3. Accessory glands
4. Lacrimal apparatus
5. Extrinsic ocular muscles

Eyelids (See Figure 1)

The primary function of the eyelids is protection, e.g., from bright light, foreign objects. During sleep the eyelids form a protective cover which prevents the very sensitive cornea from becoming dry or "desiccated"--which could lead to a loss of corneal transparency and loss of vision. When the eyes are open, normal blinking of the eyelids spreads the lubricating secretions of the eye over the surface of the eyeball.

The inner and outer angles formed by the junctions of the upper (superior) and lower (inferior) eyelids (palpebrae) have special names. The inner angle is called the medial canthus. The outer angle is called the lateral canthus. Located near the medial canthus is a structure called the plica semilunaris. The plica semilunaris is a remnant structure which corresponds to the third eyelid of lower vertebrates. Located nasally to the plica is a structure or bump called the caruncle.

The margin of each eyelid presents a row of short thick hairs--the eyelashes. At the base or root of each eyelash there are sebaceous glands which produce a lubricating fluid. If these glands become infected, it results in the formation of a sty.

There are seven layers in the eyelids. The first, or outermost layer, consists of the thinnest skin of the body. The second layer is subcutaneous connective tissue. The third layer is striated muscle. The fourth layer is submuscular connective tissue. Layer number five is the fibrous layer containing the tarsal plate. The sixth layer consists of smooth muscle. The seventh, or innermost layer, is the conjunctiva. The conjunctiva folds over onto the eye in the fornix to form the conjunctival sac.

Eyebrows

The eyebrows are located on the upper borders of the orbits. The eyebrows consist of a thickened ridge of skin covered with short hairs. This diverts perspiration from the eye.

Accessory Glands

The accessory glands may be divided into three groups, i.e., the meibomian or tarsal glands, the ciliary or sweat glands, and various conjunctival glands. The most important of these are the meibomian glands. The ducts of the meibomian glands open on the edge of the eyelid. The oily substance secreted by the meibomian glands lubricates the lid margins and prevents adhesion of the eyelids.

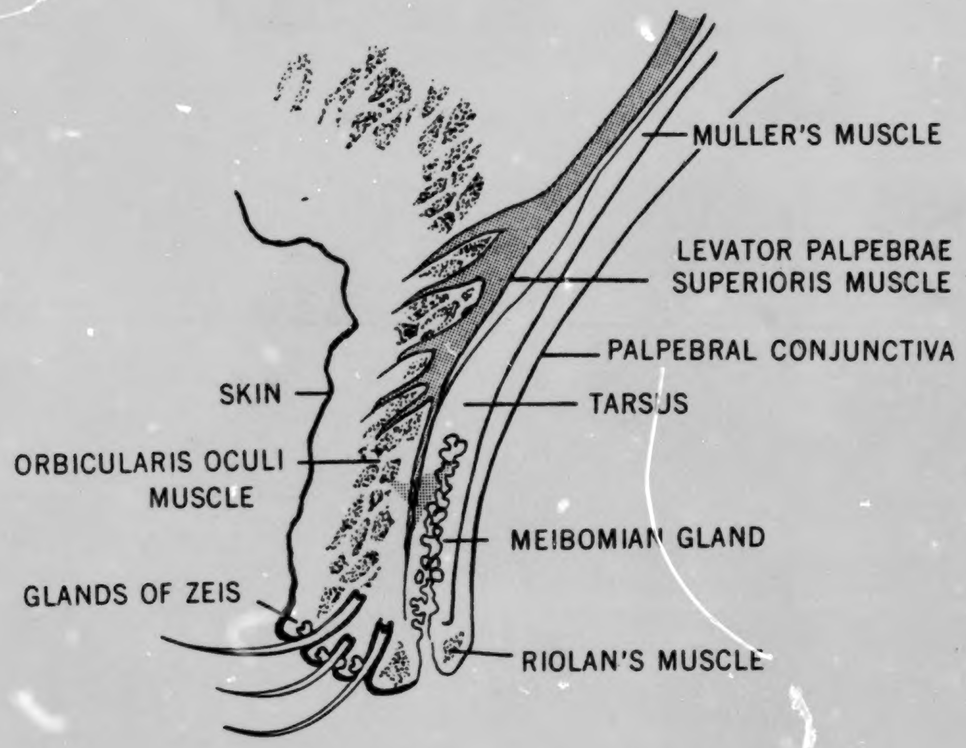
MULLER'S MUSCLE
LEVATOR PALPEBRAE SUPERIORIS MUSCLE
PALPEBRAL CONJUNCTIVA
SKIN
TARSUS
ORBICULARIS OCULI MUSCLE
MEIBOMIAN GLAND
GLANDS OF ZEIS
RIOLAN'S MUSCLE

Figure 1

Lacrimal Apparatus (See Figure 2)

The lacrimal apparatus is made up of seven structures: the lacrimal gland, lacrimal canals, conjunctival sac, puncta, canaliculi, lacrimal sac, and the nasolacrimal duct.

The lacrimal gland is located under the frontal bone at the upper and outer angle of the orbit. It is roughly the size and shape of an almond. Six to 12 ducts lead from the gland to the conjunctival surface of the upper lid. The lacrimal gland secretes just enough tears to keep the eye moist. After passing over the surface of the eyeball, the tears are sucked through the puncta into two tiny canals called canaliculi which convey the tears into the lacrimal sac. The tears then drain slowly into the nose by way of the nasolacrimal duct.

The purpose of the lacrimal secretion (tears) is to keep the eye moist and to help remove foreign bodies, dust, etc. Ordinarily the secretion evaporates or is carried away as fast as it forms; but, under certain conditions, such as when the eye is irritated or during painful emotional states, the secretion of the lacrimal gland exceeds the drainage of the nasolacrimal duct and the tears accumulate in the conjunctival sac, finally overflowing upon the cheeks.

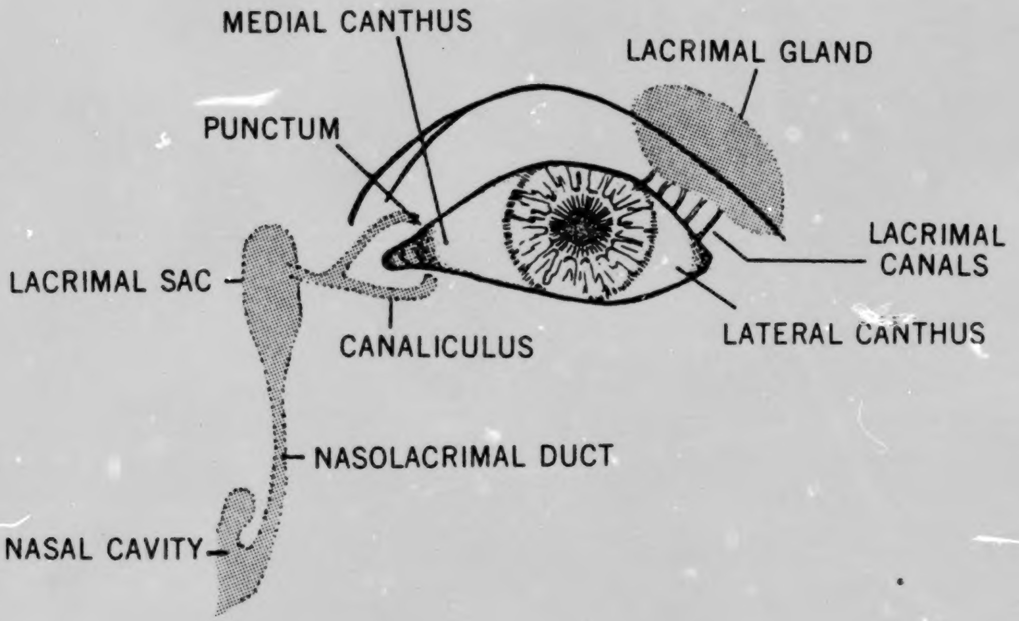

Figure 2

Extrinsic Ocular Muscles

The extrinsic muscles of the eye are simply those muscles responsible for the movement and coordination of the two eyes. There are six extrinsic (extraocular) muscles which product movement and coordination of the eyes. These muscles are located and attached to the outside of the eyeball within the bony cavity in which the eye itself is contained. The anatomy and physiology of these muscles will be discussed in a subsequent section.

Sometimes the muscles of the eyelids are discussed as extrinsic ocular muscles. If you will look at Figure 1, you will see the location of these muscles. The orbicularis oculi muscle is a sphincter-like muscle which closes the lids. Riolan's muscle functions to bring the margins of the lids together as the eyes close. The levator palpebrae superioris is responsible for opening the eyes and it is assisted somewhat in this by Mueller's muscle.

EXERCISE 1

Answer the following questions in the spaces provided.

1. List the ocular adnexa.

2. The primary function of the eyelids is ____________________.

3. Tears are produced by the ____________________ gland.

4. Located on the margins of the eyelids near the medial or inner canthus are two small openings called ____________________. These two openings permit drainage of the tears into the superior and inferior ____________________.

5. The duct which drains tears from the lacrimal sac into the nasal cavity is called the ____________________ duct.

6. The palpebrae are also called the ____________________.

7. The accessory structures or appendages of the eye are called the ____________________ ____________________.

8. The ____________________ canthus is located on the outer angle formed by the upper and lower eyelids.

9. The small reddish bump located at the medial canthus is called the ____________________.

10. The ____________________ ____________________ is a vestigial structure corresponding to the third eyelid of lower vertebrates.

11. The innermost layer of the eyelid is the conjunctiva. The pocket formed by the fold of conjunctiva located between the eyeball and the eyelid is called the ____________________ sac.

12. A sty is produced when a small sebaceous gland located at the root of an ____________________ becomes infected.

13. The purpose of the lacrimal secretion is to keep the eye ____________________ and to help wash away ____________________ ____________________ which irritate the eye.

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14. A blocked nasolacrimal duct would produce ______________________________

____.

15. If the eyelids did not close properly due to paralysis of the orbicularis oculi muscle, the cornea would become dessicated and possibly lose its

____.

16. The levator palpebrae superioris muscle __________________________ the upper eyelid.

17. The __________________________ gland produces an oily secretion which prevents the margins of the eyelids from sticking.

THE BONY ORBIT

The bony orbit is that portion of the skull which houses the eyeball, extraocular muscles, optic nerves, lacrimal gland, lacrimal sac and orbital fat. The purpose of the orbit is to provide protection, support and attachment for muscles, eyeball, nerves and blood vessels which pass through the orbital cavity.

Each orbit is shaped like a four-sided pyramid; the wide portion being the aditus orbita or opening for the eyeball, and the narrow portion pointing toward the back of the head (Figure 3). There are four walls in each orbit, a floor, roof, lateral and medial wall.

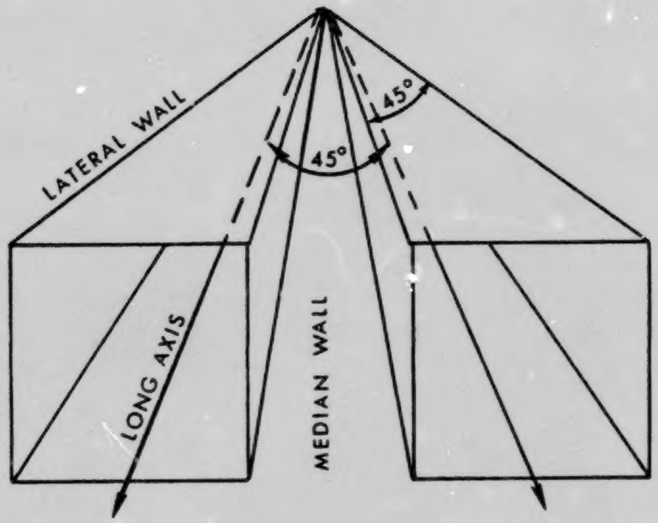


Figure 3

There are seven bones per orbit. If the bones which make up both orbits are considered, a total of 11 bones make up both orbits. (Figure 4) The roof is formed by the orbital portion of the frontal bone, and the orbital plate of the lesser wing of the sphenoid bone. The lateral (outside) wall is formed by the orbital plates of the zygomatic bone (temporal bone) and the greater wing of the sphenoid bone. This is the strongest of the four walls. The floor of the orbit is composed of three bones, the zygomatic, maxilla (upper jaw) and palatine. The thinnest wall is the medial (inside) wall. It is formed by the orbital processes of the maxilla, the lacrimal bone, the ethmoid bone, and the sphenoid bone.

The seven bones which make up each orbit are then:

- Frontal
- Sphenoid
- Ethmoid
- Zygomatic (temporal)
- Maxilla (upper jaw)
- Lacrimal
- Palatine

The frontal, sphenoid, and ethmoid bones contribute to both orbits.

All of the bones are covered with a tissue called periosteum.

There are several openings in each orbit. The largest, the aditus orbita, has already been mentioned. The remaining openings are divided into fissures (which look like cracks) and foramina (which look like holes). There are nine fissures or foramina per orbit. Each of these openings transmit nerves, arteries, and/or veins to and from the inside of the orbit. The names of these openings may be found in Figure 4.

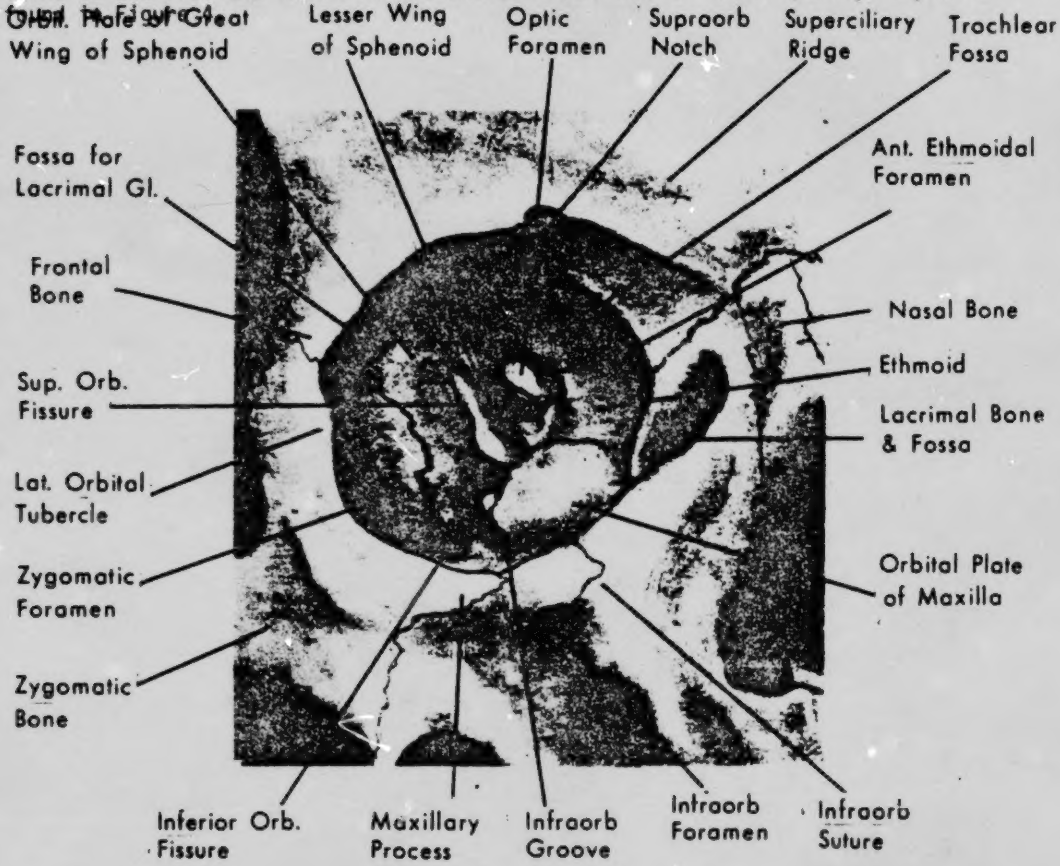

Orbit. Plate of Great Wing of Sphenoid
Lesser Wing of Sphenoid
Optic Foramen
Supraorb Notch
Superciliary Ridge
Trochlear Fossa
Fossa for Lacrimal Gl.
Ant. Ethmoidal Foramen
Frontal Bone
Nasal Bone
Ethmoid
Sup. Orb. Fissure
Lacrimal Bone & Fossa
Lat. Orbital Tubercle
Orbital Plate of Maxilla
Zygomatic Foramen
Zygomatic Bone
Inferior Orb. Fissure
Maxillary Process
Infraorb Groove
Infraorb Foramen
Infraorb Suture

Figure 4

EXERCISE 2

Answer the following questions in the spaces provided.

1. The ethmoid bone forms part of the ______________________________ wall of the orbit.

2. The orbit is shaped like a four-sided ______________________________.

3. List the seven bones of each orbit.

4. Three bones are common to both orbits. They are:

5. Openings in the orbital wall which look like elongated holes are called

______________________________. Openings in the orbital wall which appear more like round holes are called ______________________________.

6. The lacrimal gland is located in a fossa of the ______________________________ bone.

THE OCULAR TUNICS (Figure 5)

The eyeball is composed of three coats or tunics. From the outside of the eyeball inward, these coats are called the:

1. Fibrous tunic

2. Vascular tunic

3. Nervous tunic

The Fibrous Tunic

The outermost layer or tunic of the eye is called the FIBROUS TUNIC. The function of this tunic is protective. The posterior 5/6 of the fibrous tunic is white and opaque, and is called the SCLERA. The anterior 1/6 is transparent and is called the CORNEA.

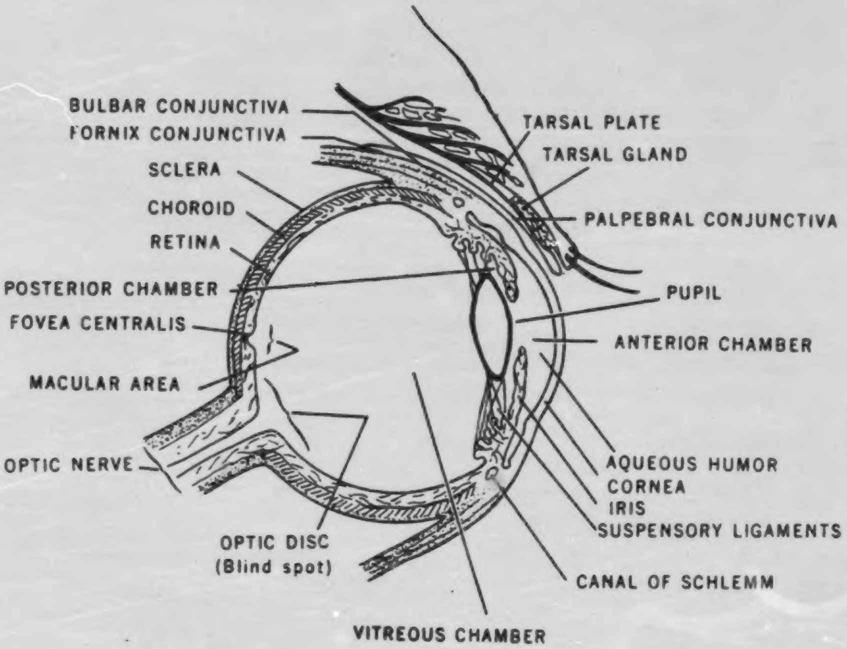

BULBAR CONJUNCTIVA
FORNIX CONJUNCTIVA
SCLERA
CHOROID
RETINA
POSTERIOR CHAMBER
FOVEA CENTRALIS
MACULAR AREA
OPTIC NERVE
OPTIC DISC
(Blind spot)
TARSAL PLATE
TARSAL GLAND
PALPEBRAL CONJUNCTIVA
PUPIL
ANTERIOR CHAMBER
AQUEOUS HUMOR
CORNEA
IRIS
SUSPENSORY LIGAMENTS
CANAL OF SCHLEMM
VITREOUS CHAMBER

Figure 5

The cornea is a little more steeply curved than the rest of the eye, and so appears as a slight bulge if viewed from the side. Most corneas are slightly oval in shape rather than round - the horizontal meridian is slightly longer than the vertical. The average diameter is 11-12 mm.

The center of the cornea is thinner than the periphery (.8 mm and 1 mm).

Most refraction of light rays occurs at the cornea. The cornea has a refractive power of about +45 D. (The crystalline lens has a power of about +12D.

The limbus is the transition zone between the cornea and sclera. It can be seen as the grayish or translucent ring around the circumference of the cornea.

Histologically the cornea has five layers. Beginning with the outer layer they are: the surface epithelium, Bowman's membrane, stroma (substantia propria), Descemet's membrane, and endothelium (mesothelium). The surface epithelium is made up of only five layers of cells which are easily abraded or rubbed off by foreign bodies or ill-fitting contact lenses. Fortunately, the cornea heals very quickly--often in a matter of hours unless the deeper layers are injured. If deeper layers are lacerated, scarring may occur.

The posterior 5/6 of the globe is the sclera. The anterior portion of the sclera makes up the white of the eye.

The sclera may appear bluish in young children due to its thinness and the uvea showing through. Fat deposits may cause the sclera to appear yellowish in old age.

The sclera is thickest in its posterior portion (1 mm) and thins as it is traced forward. It is very thin at the insertion of the muscles.

The sclera is pierced by many holes at the posterior pole where the optic nerve attaches to the eyeball. These holes allow the axones of the nerve to pass through.

There are three major classes of openings in the sclera--posterior, middle and anterior, through which pass certain blood vessels and nerves.

The CONJUNCTIVA is an epithelial membrane which covers the front of the eye and is reflected to the back surface of the lids. The three divisions of conjunctiva are: Bulbar, Fornix, and Palpebral.

The Vascular Tunic

The UVEAL TRACT or VASCULAR TUNIC is located just beneath the fibrous tunic. The uveal tract is divided into three parts--the CHOROID, the CILIARY BODY and processes, and the IRIS. The color of the uveal tract is dark brown due to the presence of melanin, a pigment.

The choroid runs from the optic nerve head to the ora serrata, and is attached to the globe at these two places.

Histologically, the choroid is composed of blood vessels and capillary nets.

The function of the choroid is to supply nutriment to the other layers of the eye.

The ciliary body runs forward from the ora serrata to the iris.

Histologically, the ciliary body is composed of blood vessels and muscle fibers. The muscle fibers are attached to tiny string-like extensions called ciliary processes which insert in the periphery of the lens capsule. The ciliary processes are also commonly called suspensory ligaments, or the zonules of Zinn.

The function of the ciliary body is to cause changes in the shape of the lens. This is the accommodative (focusing) mechanism of the eye, and will be discussed more fully later.

The iris is the most anterior portion of the vascular tunic, and is attached at its periphery to the ciliary body.

There is a hole in the center of the iris called the pupil.

The function of the iris is to limit light entering the eye, and to regulate the amount of light by varying the size of the pupil.

When we speak of the vascular tunic of the eye, we must remember that this structure is an extension of the vascular system of the body. Since the body is supplied by a single closed-circuit vascular system, the eye may be affected by incidents occurring in other parts of the body. Also, the vascular tunic of the eye does not nourish all of the ocular structures. The eyelids, the muscles that move the eye, and most of the other structures in the orbital area receive nourishment from branches of the ophthalmic artery and the infraorbital artery. After passing through capillaries located in the orbital tissues, the blood leaves the orbital area by way of the vortex and ophthalmic veins.

The Nervous Tunic

The RETINA or NERVOUS TUNIC is a direct extension of the brain, and is the innermost of the three tunics. It is attached to the rest of the eye at the optic nerve head and at the ora serrata. In the healthy eye, the retina is transparent.

The retina has several landmarks--the optic nerve head-which has no visual receptors, and the macula lutea (optical center of the retina) which has a depression called the fovea centralis. Our clearest vision is in the area of the fovea centralis (all cones). The ora serrata is the most anterior portion of the sensory portion of the retina.

The retina is divided into 10 layers. The outermost layer is a layer of pigment. Touching the inner side of the pigment layer is the layer of rods and cones. Inside of this layer are layers of membranes and cell nuclei, and a layer where the rods and cones synapse with bipolar cells. There is also a layer where the bipolar cells synapse with ganglion cells. The ninth layer is the nerve fiber layer--axones of the ganglion cells. The 10th layer is a membrane separating the retina from the vitreous.

The light-sensitive elements of the retina are the rods and cones. Light passes through these cells "backwards" to stimulate the cells. These cells are named "RODS" or "CONES" because they look like rods or cones....There are other differences, however.

Cones contain iodopsin, are more prevalent near the fovea, used for color vision, "low grain", used under photopic (high light level) conditions.

Rods contain rhodopsin, are not found in the fovea, are more numerous than cones (6 million cones vs 120 million rods per retina), see only black and white, "high grain", used under low light levels (scotopic conditions).

The "duplicity theory" is a statement that there are two visual systems - one for low light levels (scotopic) and one for high light levels (photopic). Support for this theory includes the dark adaptation curve break. (Figure 6)

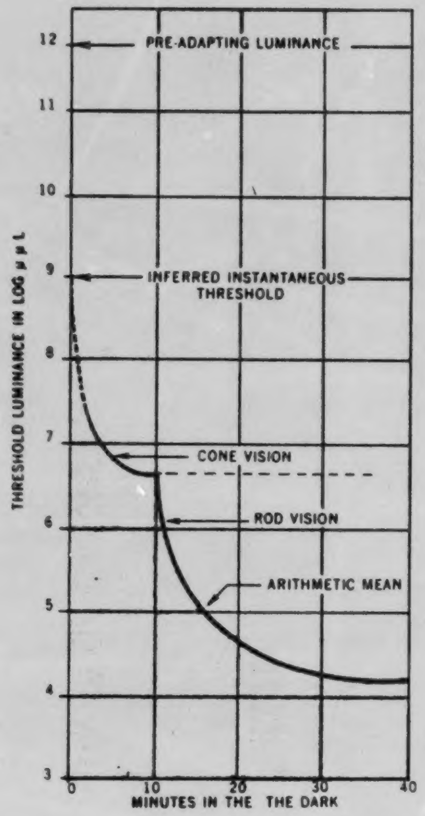


Figure 6

Since there are no rods or cones in the optic nerve head, there is a "blind spot" in each eye - an area where nothing is seen. This is the physiological scotoma.

As mentioned before - vision is sharpest (visual acuity is highest) at the fovea - it falls off as the periphery is approached. Night vision, however, is sharpest about 2° from the fovea.

EXERCISE 3

Answer the following questions in the spaces provided.

1. List the three ocular tunics.

2. The transparent portion of the outer tunic is called the ______________________.

3. The light receptors in the retina are called __________________________ and __________________________. The __________________________ function in dim light. The _______________________________ are sensitive to color.

4. The pupil is located in the __________________________________.

5. The conjunctiva has three divisions. They are:

6. The superficial layer of the cornea is called ______________________________.

7. The muscular structure responsible for changing the shape of the crystalline lens is called the ___________________________ ___________________________.

8. The portion of the retina with the best vision is the ______________________ __________________________.

9. The transition zone between the sclera and the cornea is called the ________________.

10. The uveal tract has three parts: the ____________________________, the ____________________ ____________________, and the ______________________.

THE EXTRINSIC OCULAR MUSCLES AND OCULAR MOTILITY

Movement of either eye is affected by six extraocular or extrinsic ocular muscles which act in coordination with the muscles of the opposite eye. The extraocular muscles should be differentiated from intraocular (intrinsic ocular) muscles located within the eyeball. Remember that the intraocular muscles control pupil size and the focus of the eye, while the extraocular muscles control eye movement, i.e., the direction of gaze.

The extraocular muscles lie within the bony orbit. They are organized, more or less, into a loose umbrella-like bundle among the orbital fat, the orbital blood vessels and nerves. A layer of tissue, Tenon's capsule, surrounds the extraocular muscles. Tenon's capsule is attached to the sclera near the limbus and runs posteriorly where it attaches to the optic nerve. The extraocular muscles extend through sleeve-like projections of Tenon's capsule from the walls of the orbit to attachments on the eyeball. The relative positions of the muscle attachments can be seen in Figures 7 and 8.

The extraocular muscles may be subdivided under two headings--the recti and the obliques. The recti are:

Superior Rectus (S.R.)
Inferior Rectus (I.R.)
Medial Rectus (M.R.)
Lateral Rectus (L.R.)

The obliques are:

Superior Oblique (S.O.)
Inferior Oblique (I.O.)

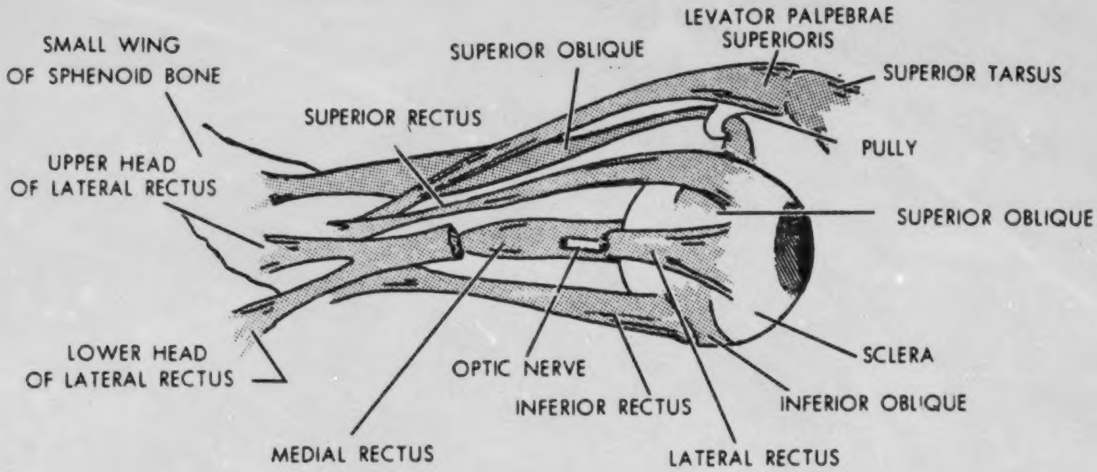

LEVATOR PALPEBRAE SUPERIORIS
SMALL WING OF SPHENOID BONE
SUPERIOR OBLIQUE
SUPERIOR TARSUS
SUPERIOR RECTUS
PULLY
UPPER HEAD OF LATERAL RECTUS
SUPERIOR OBLIQUE
LOWER HEAD OF LATERAL RECTUS
OPTIC NERVE
SCLERA
INFERIOR RECTUS
INFERIOR OBLIQUE
MEDIAL RECTUS
LATERAL RECTUS

Figure 7

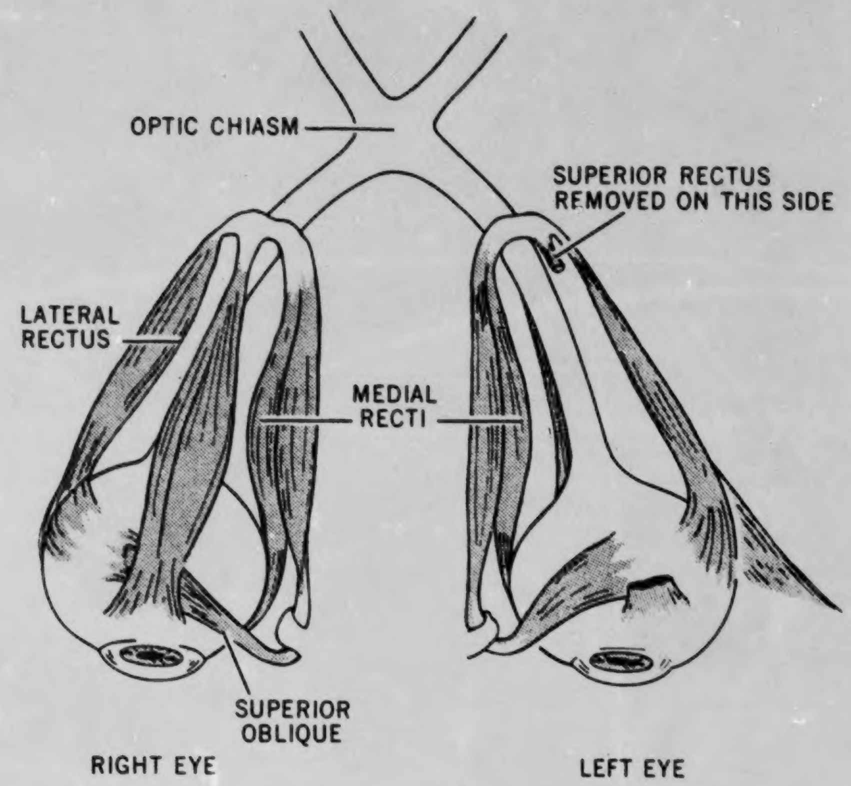


Figure 8

A muscle can only perform work by shortening, and pulling whatever is attached to it. The action of an extraocular muscle is then dependent upon the place where the muscle is anchored to the bony orbit (origin) and the effective point of insertion of the muscle into the globe.

The four recti originate from the apex of the orbit, around the optic nerve, and travel forward to insert near the equator (Figures 7 and 8). The superior oblique also originates from this area, but runs through a little circle of cartilage called the trochlear pulley before inserting in the eye just below the superior rectus. The trochlear pulley is located in the superior nasal (up and toward the nose) portion of the bony orbit.

The only extraocular muscle that does not originate from the orbital apex is the inferior oblique. This muscle originates from the floor of the orbit, near the nasal portion of the orbital margin, and inserts just under the inferior rectus.

Study the diagrams in this study guide and workbook, and look at the eye models in class so that you become familiar with the relations of the extraocular muscles to each other, to the globe, and to the orbit.

ZP- 76-569

Each muscle has a specific job to do in order to make the eye move. This is called the muscle action and is named after the movement of the eye which it causes. If a muscle turns the eye up, it is called an elevator; if the eye is turned down, the action is depression; if the eye is turned out (temporally) the action is abduction; and if the eye is turned in (nasally) the action is adduction. If the eye is rotated so that the top of the iris seems to move in, while the bottom moves out, the action is called intorsion. If the top goes out and the bottom moves in, the action is extorsion.

Each muscle can perform more than one action. The primary action of a muscle is the main action performed by that muscle when it moves from the primary position (the straightforward position).

A secondary action is an additional action performed by a muscle while it is performing its primary action. For instance, when the eyes are in the primary position (straight ahead), the superior rectus is the main elevator. The primary action of the superior rectus is elevation, but due to the angles of the orbits (Figures 3 and 8), the superior rectus slightly adducts and intorts the eye at the same time. These are secondary actions.

The primary and secondary actions of the extraocular muscles are listed below:

MUSCLE	PRIMARY ACTION	SECONDARY ACTION
Lateral Rectus	Abduction	None
Medial Rectus	Adduction	None
Superior Rectus	Elevation	Adduction and intorsion
Inferior Rectus	Depression	Adduction and extorsion
Superior Oblique	Intorsion	Depression and abduction
Inferior Oblique	Extorsion	Elevation and abduction

Innervation to the superior rectus, medial rectus, inferior rectus, and inferior oblique is by means of the third cranial nerve (oculomotor nerve). The lateral rectus is innervated by the sixth cranial nerve (abducent nerve) and the superior oblique is innervated by the fourth cranial nerve (trochlear nerve). An easy way to remember this is to use the formula:

$(LR_6SO_4)_3$

which means that all of the muscles are innervated by the third cranial nerve, except the lateral rectus (VI), and the superior oblique (IV).

Whenever two muscles work together to help perform the same action in the same eye, they are called synergists. For example, the superior rectus and inferior oblique of the same eye act together synergistically to elevate the eye. Whenever two muscles act in opposition to each other in the same eye, they are called antagonists. For example, the superior and inferior recti of the same eye are antagonists, i.e., while the superior rectus is acting to elevate the eye, the inferior rectus tends to hold back that action. Sherrington's Law of Reciprocal Innervation states that antagonists never contract equally together; one antagonist contracts while the other relaxes.

Two muscles which perform the same action in opposite eyes are called yoked muscles. For example, the left lateral rectus (LLR) and the right medial rectus (RMR) are yoked to turn the eyes left. Other yoked pairs are the LSR-RIO, LIR-RSO, RSR-LIO, and RIR-LSO. Hering's Law of the Ocular Movements states that the movements of the two eyes are equal and symmetrical--this is a result of equal innervation to the paired or yoked muscles.

Controlled movements of the two eyes generally fall into two categories referred to as versions and vergences. A version is a conjugate binocular movement, i.e., both eyes are parallel and are moving together in the same direction--right, left, up, or down. A vergence is a disjunctive binocular movement, i.e., both eyes are converging or diverging. It is normal for your eyes to converge (turn in) when you look at something very close, and it is just as normal for your eyes to diverge back to parallelism later when you gaze at something far away. Convergence and divergence are examples of disjunctive movements of the two eyes.

Anomalies of Ocular Motility

Sometimes a muscular or neural anomaly develops in which the line of sight of one eye fails to intersect the object of fixation. If one eye fixates (looks at) an object, and at the same time it is found that the line of sight of the other eye is directed to the left, right, above, or below the object of regard, the patient is said to have a deviated eye. This deviation is called a heterotropia (or strabismus or squint).

You should know and understand the following classifications of heterotropia:

ESOTROPIA. One eye is deviated "in" (i.e., toward the nose) relative to the fixating eye.

Note that synonyms for esotropia are convergent strabismus, convergent squint, and crossed-eye.

EXOTROPIA. Relative to the fixating eye, the other eye is deviated out.

Synonyms for exotropia are divergent strabismus, divergent squint, wall-eye.

HYPERTROPIA. Relative to the fixating eye, the remaining eye is deviated upward.

HYPOTROPIA. Relative to the fixating eye, the remaining eye is deviated downward.

Esotropia and exotropia are lateral deviations while hypertropia and hypotropia are vertical deviations. It is possible for a patient to have a strabismus made up of both a lateral and a vertical component, e.g., a right hyper-exotropia.

Based on the nature of fixation the above categories of strabismus can be further classified as monocular or alternating:

MONOCULAR STRABISMUS. One eye is always the fixating eye and the other eye is always the deviating eye. Such patients usually have good vision in one eye and poor vision in the other eye. You would normally expect the eye with the poorer vision to be the deviating eye.

ALTERNATING STRABISMUS. These patients have no preference of one eye over the other. They can alternately fixate with either eye.

There are many other ways of classifying strabismus, but for now the above categories are what you need to know. Test your comprehension at this point by asking yourself to describe a right esotropia. This term should tell you that the patient has a right eye which is deviated in. Because it is a right esotropia, (in other words, the patient does not alternate fixation), the patient prefers to fixate with his left eye. Therefore, it is also very likely that he has better vision with his left eye.

Muscular anomalies are not always manifest deviations such as we have described with the heterotropias. There are also latent muscle deviations which are only manifest when the eyes are dissociated, or kept from normal binocular vision. One way to interrupt normal binocular vision (dissociate the eyes) is simply to cover one eye with an occluder. If the covered eye then assumes a position of deviation, in relation to the eye not covered, the patient has a latent muscle deviation. Upon removal of the cover (and a return to normal binocular vision), the eye that was deviated while it was behind the cover will almost immediately return to a normal position relative to the other eye. These muscle deviations which occur as a result of dissociation are called heterophorias.

Heterophorias are classified according to the position the eyes would assume under conditions of dissociation. However, be careful not to confuse this with the classification of heterotropias which is under manifest conditions. You should know and understand the following classifications of heterophoria:

ESOPHORIA. A latent tendency for the lines of sight to deviate inward relative to each other under conditions of dissociation.

EXOPHORIA. A latent tendency for the lines of sight to deviate outward relative to each other under conditions of dissociation.

RIGHT HYPERPHORIA. A latent tendency for the line of sight of the right eye to deviate upward relative to the line of sight of the left eye under conditions of dissociation.

LEFT HYPERPHORIA. A latent tendency for the line of sight of the left eye to deviate upward relative to the line of sight of the right eye under conditions of dissociation.

ORTHOPHORIA. Under conditions of dissociation there is no deviation of the lines of sight one from the other. In other words, both eyes remain directed toward the object of regard even though one eye is dissociated from the other as by an occluder--there is no latent deviation.

Although some authors define the term "hypophoria", common custom describes any vertical phoria in terms of "hyperphoria". Insofar as the vertical phorias are concerned, it is customary to record a left hypophoria as a right hyperphoria and a right hypophoria as a left hyperphoria. (The same thing is true in alternating strabismus containing a vertical component--i.e., the vertical component is described in terms of hypertropia rather than hypotropia.)

Except for the "hyper" conditions, phorias are not classified according to which eye is affected. In other words, lateral phorias are recorded simply as "esophoria" or "exophoria" with no breakdown as to right or left unless there is also a vertical component present. It is possible for the patient to exhibit both vertical and lateral components--a right hyper-exophoria, for example.

EXERCISE 4

Answer the following questions in the spaces provided.

1. List the six extraocular muscles responsible for eye movement.

2. The superior oblique runs through a circle of cartilage called the ______________ pulley.

3. Paralysis of the third cranial nerve would produce the loss of action of how many extraocular muscles in one eye? ______________________

4. Two muscles which perform the same action in opposite eyes are called ____________ muscles.

5. If the right eye fixates a small target located across the room and at the same moment it is noticed that the line of sight of the left eye is deviated to the left, the condition is ________________________________.

6. A heterotropia is a manifest deviation of the eyes; a heterophoria is a ___________________________ deviation which can only be elicited when the eyes are in a condition of ____.

7. When there is no deviation of the lines of sight either under normal conditions or under conditions of dissociation, the muscle balance is called ____________________.

8. Normally movements of the two eyes are equal and symmetrical as a result of equal innervation to yoked muscles. This fact is a statement of ___________________'s Law.

9. According to common custom, a left hypophoria should be recorded as a ______________________ ________________________.

10. A head injury which results in the loss of the sixth cranial nerve on the left side would cause paralysis of the ______________________ ______________________ ___________________________ muscle. In which direction of gaze would this patient be most likely to report double vision?

INSTRUMENTATION AND PROCEDURES USED TO DETECT AND MEASURE ANOMALIES OF OCULAR MOTILITY

Now that you know the names of two common muscular anomalies, the next step is to learn some tests designed to identify and differentiate tropias and phorias. In this section we will discuss five such tests--The Cover Test, Red Lens Test, Worth 4-Dot Test, Diagnostic H Test, and the Near Point of Convergence Test.

Cover Test

The cover test is designed to detect both tropias and phorias, and may be modified to differentiate the two. The cover test is divided into two parts--the alternate cover test and the cover-uncover test. The cover test is to be performed on essentially all physicals that are performed with the optometry clinic as consultant.

The first portion of the test is the alternate cover test at 20'. The patient is instructed to fixate a spot of light on the wall about 20' away while the examiner alternately covers one eye and then the other with an occluder. If the patient is ortho, no movement will be seen when switching the occluder from one eye to the other. If the patient has a muscle imbalance, a movement will be noted.

If the eye turns in upon uncovering, it must have turned out when covered (disassociated); this means that the patient is exo. Conversely, if the eye turns out upon uncovering, it was in when disassociated, and the patient is eso. A similar relation exists for vertical imbalances.

Once the direction of the anomaly has been established, the cover-uncover test is used to determine whether the imbalance is a tropia or a phoria. In this portion of the test, the patient is permitted to fixate binocularly, then one eye is occluded. The occluder is then removed for a few seconds and placed over the other eye. The examiner is to observe the eye which is not being covered. If that eye moves when the opposite eye is covered, the condition is a heterotropia. If the eyes were able to binocularly fixate between occlusions, the condition is a heterophoria. (See Figure 3-15, AFM 160-17 insert)

If the alternate cover test reveals no movement, enter "CT: ortho" on item 62, SF 88, or appropriate blocks on DD 741 or local form. If movement is seen, enter type and direction. The amount and character will be entered in item 73. (See Paragraph 3-11i in the AFM 160-17 insert.)

Red Lens Test

The Red Lens Test is performed with FSN6515-346-2800, Diplopia Test, Red Lens. It is routinely performed for flying physicals only. This test is designed to detect diplopia (double vision) when the patient is looking in a direction other than straight ahead.

The patient is seated 30" away from a tangent screen, holds the red lens over one eye, and observes a dim source of light projected onto the tangent screen (or held in front of it). The light should appear pink to the patient, and he should report changes in color (suppression) or diplopia. If suppression or diplopia occurs within about 20" from the center of the screen in any of the six cardinal directions, note and record on item 68, SF 88, otherwise enter "passed" in that block. (See Paragraph 3-12 in the AFM 160-17 insert.)

Worth 4-Dot Test

The Worth 4-Dot Test (FSN6515-685-5197 test set, Binocular Vision) may be performed at nearpoint (or farpoint using projectochart). It is designed to detect suppression and/or diplopia when the patient is either looking directly at the target or in a direction other than straight ahead.

The test consists of four lighted spots or dots arranged in a baseball-diamond pattern. "Home plate" is white, "first and third bases" are green, and "second base" is red. The patient wears anaglyph glasses (special colored filters - green lens over the left eye, red lens over the right). The right eye can see only the white dot (as red) and the red dot. The left eye sees the white dot (as green) and the two green dots. A person with normal muscle balance and binocular vision would see the four dots just as he would without the glasses. If one eye is suppressed, only three or two dots would be seen, and they would be the color of the non-suppressing eye. If a high phoria or tropia were present without suppression, five dots would be seen, the pattern depending on the type of diplopia and muscle imbalance. Uncrossed diplopia (green dots seen to the left of the red) indicates an eso condition. Crossed diplopia (green dots seen to the right of the red) indicates an exo condition (Figure 9).

No item is denoted for this test on SF 88, but many local forms may have an entry entitled "4-Dot". If you are instructed to perform this test, and the form used in your clinic is a DD 741, enter your findings on the back side.

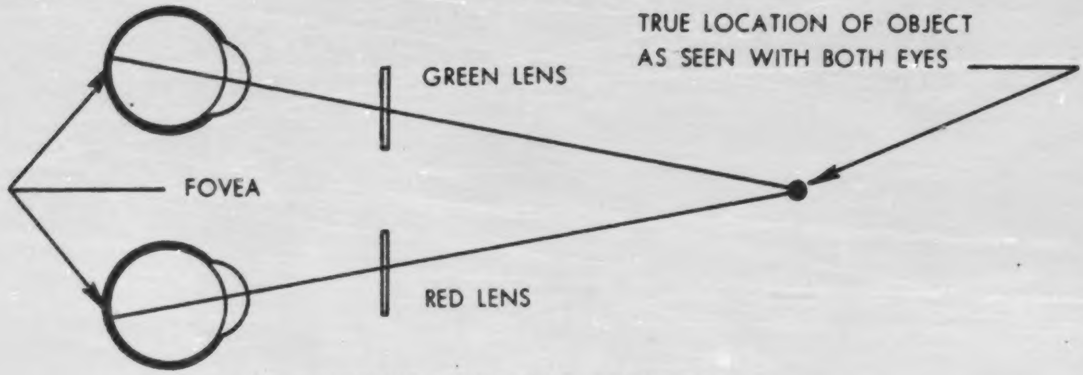
Diagnostic H Test

This test is based on the assumption that in certain positions of the eye, one of the extraocular muscles is exerting more action than the other five. Knowing which muscle is primarily responsible for a given action permits us to determine if each of the six muscles is intact.

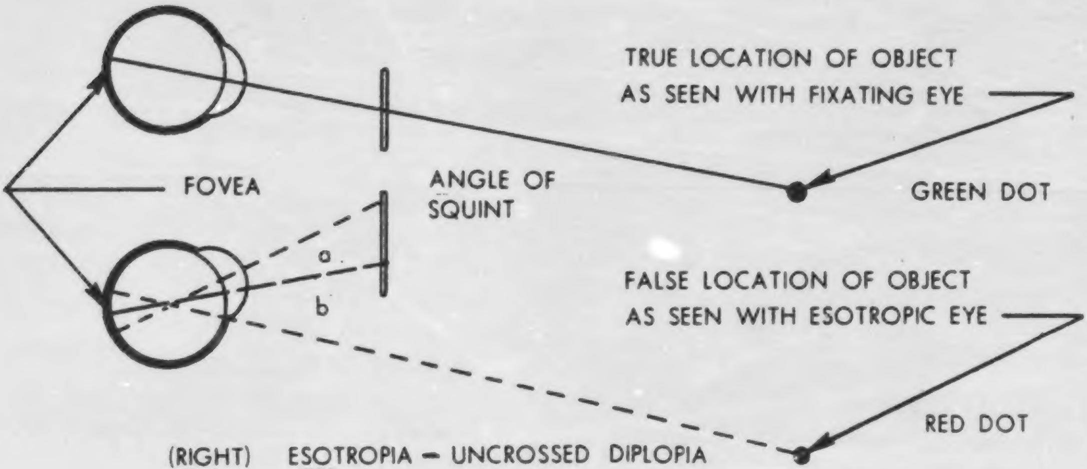
If you will closely study Figures 7 and 8, it is fairly easy to visualize the fact that the medial rectus is the muscle primarily responsible for adducting (turning inward) the eye from any horizontal position. Similarly, it can be seen that the lateral rectus is the key muscle which abducts (turns out) the eye from any horizontal position.

It is a little more difficult to isolate the other four muscles by deduction, but research indicates that when the eye is adducted approximately 50 degrees, the I.O. is the only elevator of the eye, while the only depressor is the S.O. Also, when the eye is abducted about 30 degrees, the S.R. is the only elevator, while the only depressor is the I.R.

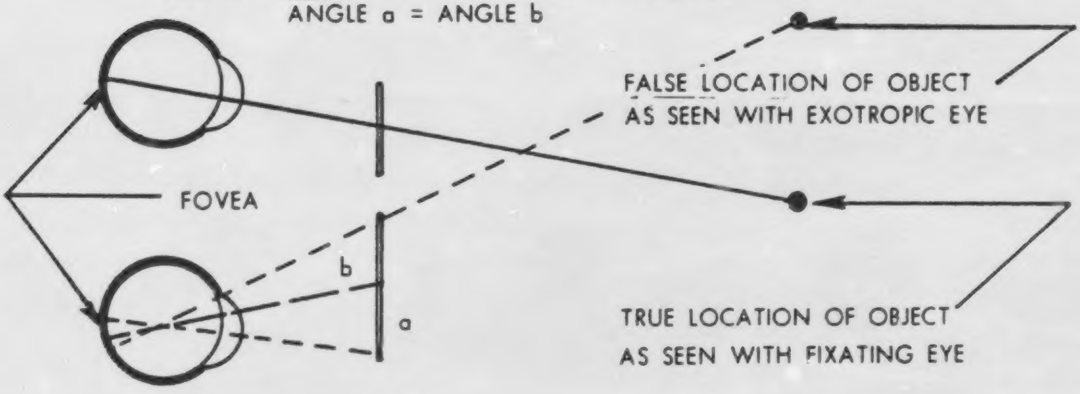
sing this knowledge, the Diagnostic H Test was devised (Figure 10).


TRUE LOCATION OF OBJECT
AS SEEN WITH BOTH EYES
GREEN LENS
FOVEA
RED LENS

NORMAL BINOCULAR VISION


TRUE LOCATION OF OBJECT
AS SEEN WITH FIXATING EYE
FOVEA
ANGLE OF
SQUINT
GREEN DOT
a
b
FALSE LOCATION OF OBJECT
AS SEEN WITH ESOTROPIC EYE
RED DOT

(RIGHT) ESOTROPIA – UNCROSSED DIPLOPIA
ANGLE a = ANGLE b


FALSE LOCATION OF OBJECT
AS SEEN WITH EXOTROPIC EYE
FOVEA
b
a
TRUE LOCATION OF OBJECT
AS SEEN WITH FIXATING EYE

(RIGHT) EXOTROPIA – CROSSED DIPLOPIA

Figure 9

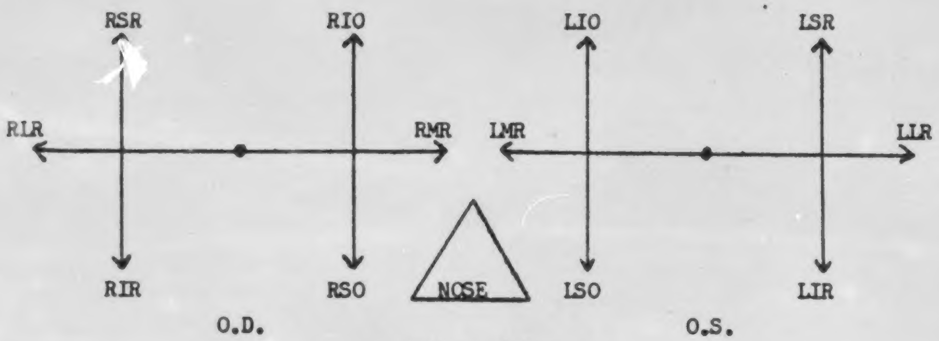


Figure 10

Figure 10

The Diagnostic H Test should be administered in a fairly well-lighted room. Seat the patient facing you and have him fixate a penlight or muscle light held at about a 24" distance in the centerline at eye level. Instruct the patient to fixate the penlight at all times.

While administering this test, observe the position of the reflection of your light from the patient's corneas (corneal reflex) in relation to some point of reference such as the pupil.

Now move the light to your right. If the patient's eyes follow the light (to about 50°-60°) his LLR and RMR are intact.

Now move the light about 50° to the left of the centerline. If the patient maintains binocular fixation, his RLR and LMR are intact.

Now elevate the light about 30° while the patient is looking right. If both eyes follow this elevation, the LIO and RSR are intact.

Depression of the fixation light about 30° while the patient is looking right checks the condition of the LSO and RIR.

Return the light to a position so that the patient is looking far left and up. This checks the LSR and RIO. Depression of the light checks the LIR and RSO.

If the patient can follow the light in all of the above mentioned positions, record results as "EOMS-Full" (Extraocular movements - Full) or "muscle action, full and unrestricted" on the DD 741 or local form.

If the patient cannot track in one or more positions, record this as "possible paresis ______________________________" and notify the doctor.

Nearpoint of Convergence Test

The last muscle test which you will learn is called the NPC or Nearpoint of Convergence. This is a test to determine how close to the eyes an object may be brought before the patient either sees double (diplopia) or stops converging (turning in or crossing) his eyes.

With the patient seated before you as in the last test, have him fixate a small target 24"-30" away. (This test is invalid for most tropes.) Slowly move the target toward the bridge of the patient's nose. The patient's eyes should converge with the inward movement of the target until a point of maximum convergence is reached. At that point the patient should report to you that he has begun to see double and you should be able to note a rather sudden divergence of the eyes. When the point of maximum convergence is reached some patients do not let their eyes diverge, but you should notice in those cases that any additional convergence closer than the point of maximum convergence does not occur and the patient will see double.

The point of maximum convergence is the NPC (or simply PC) and is measured from the bridge of the patient's nose with the aid of a millimeter rule. Record the result as PC ______________ or NPC ______________. If the PC measures 50 mm, just record the number "50"; the units are understood.

Nearpoint of convergence (PC) will be determined for all personnel being examined for flying qualification in classes I and II. Candidates for flying training will not be allowed to wear corrective lenses while being tested for nearpoint of convergence. With the zero mark of the Prince rule placed approximately 15 mm from the anterior corneal surface, the point of convergence is that point on the rule which marks the greatest convergence of the eyes. It is measured in millimeters. If correcting lenses are necessary to meet the distance or near vision acuity standards, such correction will be worn during this examination. Do not record unit of measurement on item 62, SF 88.

Prolonged repetition usually tires the extraocular muscles and gives erroneous measurements. Before an examinee is disqualified for insufficient power of convergence, he will be examined on two successive days and the nearest point of convergence recorded.

Before completing Exercise 5, study the test procedures for lateral and vertical phoria measurements described in the AFM 160-17 insert at the back of this SW (Paragraph 3-4g(1)(a) through paragraph 3-4g(2)(b) and paragraph 3-4g(5) and (6). Then study the test procedures for lateral and vertical phoria measurements described in the Keystone Telebinocular insert (Tests II, III and X). This will give you the information you will need to administer quantitative tests for heterophoria using the Vision Test Apparatus, Near and Distant (VTA-ND) and the Keystone Telebinocular. Exercise 5 will include questions pertaining to those instruments.

EXERCISE 5

Answer the following questions in the spaces provided.

1. The Cover Test can be used to differentiate between ____________ and ____________.

2. If an eye turns in when covered and then returns to the primary position when uncovered, the condition is ____________. (Assume that the other eye did not deviate from the primary position during the test.)

3. List at least eight types of muscle imbalances that can be determined by use of the Cover Test.

4. The correct patient-to-tangent screen distance to administer the Red Lens Test is ____________ inches.

5. The Red Lens Test is used to detect ____________ or ____________ in six cardinal directions of gaze.

6. The Diagnostic H Test is based on the assumption that in certain directions of gaze, one of the ____________ ____________ of an eye is more or less isolated from the rest.

7. When administering the Diagnostic H Test you find that the patient sees double when looking up and to his right, what muscles are suspected? ____________ ____________ ____________ and the ____________ ____________ ____________.

8. With reference to question 7, if the corneal reflex was centered on the right eye but decentered on the left eye in the up-right direction of gaze, which eye muscle is paretic or paralyzed? ____________ ____________ ____________.

9. When you administer the NPC Test and the point of maximum convergence is finally reached, the patient's eyes will either suddenly ____________ or remain ____________.

10. When administering the phoria tests on the VTA-ND, the instrument occluder should be in the ____________ position.

11. If a patient shows exophoria on the Cover Test, what type of muscle imbalance would you expect to find with the VTA-ND or Keystone Telebinocular? ____________

12. Fusion is suspended when the eyes are ____________.

THE OCULAR MEDIA

A general term for the transparent structures of the eye is ocular media (or refractive media). We have already discussed the first of these, the cornea. The other ocular media are the aqueous humor, the crystalline lens, and the vitreous humor (Figure 5).

Aqueous Humor

The aqueous humor may be found throughout the interior of the eye, but is primarily found in the anterior and posterior chambers (see Figure 5). The anterior chamber is the area between the back surface of the cornea and the front surface of the iris. The posterior chamber is a small space just behind the iris and in front of the crystalline lens.

Most authorities agree that the aqueous is produced continuously in the posterior chamber by the vascular plexus of the ciliary body. The aqueous flows into the anterior chamber through the pupil, and it is drained from the eye through the canal of Schlemm located in the angle of the anterior chamber in the trabecular network.

Whenever aqueous is overproduced, or whenever the drainage system fails, the excess of aqueous fluid causes a buildup of intraocular pressure (pressure inside the eye) which results in damage to the visual receptors in the retina. Abnormally high intraocular pressure is called glaucoma.

The aqueous is clear and colorless with a watery-like consistency. Chemically it consists of 99% water. It has an index of refraction of 1.3336. In addition to being a refracting medium for the eye, aqueous probably nourishes the crystalline lens and cornea.

Whenever aqueous is lost because of surgery or perforating injury, the lost aqueous will be replaced in a few hours once the wound is closed.

Crystalline Lens

The little lens contained in the eye just behind the iris is called the crystalline lens because of its clarity and transparency. The crystalline lens is an elastic, biconvex structure composed of an outer capsule which surrounds the cortex and nucleus. The cortex and nucleus make up the body of the lens.

The lens is about 10 mm in diameter and approximately 5 mm thick. Both the diameter and thickness of the lens vary according to the state of accommodation (or focus of the eye). (We will discuss accommodation in a later unit.) The crystalline lens is suspended within the eye immediately behind the iris by the suspensory ligaments (or zonules of Zinn). The suspensory ligaments link the lens to the ciliary muscle.

The crystalline lens has an index of refraction in its cortex of about 1.386; index of the nucleus is about 1.406. Total dioptric contribution to the eye is approximately +12D.

As previously stated, the lens is normally clear and transparent, however, certain diseases or injuries may cause part or all of the lens to become opaque or translucent. The condition in which the lens is partially or entirely opacified is called cataract. Remember that cataracts are not external problems of the eye, but rather internal problems.

Most cataracts cannot be prevented or kept from progressing. Once they have progressed to a certain stage, surgical removal is usually indicated. When cataract surgery becomes necessary, the entire crystalline lens must be removed. Usually cataracts are seen in elderly patients.

Vitreous Humor

Just behind the crystalline lens, and filling the posterior 5/6 of the eye, is the vitreous humor. The vitreous humor fills the vitreous chamber. The chemical composition is very similar to aqueous (99% water), but the vitreous is a gel--a jelly-like substance.

The vitreous adheres closely to the retina, especially at the ora serrata and around the optic disc. A firm attachment may sometimes be found around the macula. Unlike aqueous, if vitreous is lost through injury or surgery of the eye, it is not replaced by the eye.

The index of refraction of the vitreous is from about 1.3345 to 1.3348.

EXERCISE 6

Answer the following questions in the spaces provided.

1. A general term for the transparent structures of the eye is ____________________

________________________.

2. The aqueous flows from the posterior chamber into the anterior chamber by way of the ____________________________________.

3. The aqueous is drained from the eye through the ____________________ of

_________________________.

4. When the crystalline lens loses its transparency, the condition is called a

______________________________________.

5. _________________________________ humor is reproduced in the eye throughout life, but ___________________________________ humor is not.

6. _________________________________ humor is watery in consistency, but

__________________________________ humor has a __________________________ consistency.

7. Vitreous humor occupies the _________________________________ chamber of the eye.

8. List four ocular media.

NERVOUS SYSTEM DIVISIONS OF THE EYE AND ADNEXA

As you learned in Medical Service Fundamentals (3AQR90010), the nervous system *of the body* is divided into divisions according to function. This unit of instruction will familiarize you with nervous system groupings of the eye. You need this information to understand how the eye functions and how certain ophthalmic drugs work.

Discussion

You will recall that the central nervous system (CNS) consists of the brain and spinal cord. The peripheral nervous system (PNS) consists of the nerve trunks which extend from the CNS. These nerve trunks are of three basic types according to their function:

1. Motor fibers. These nerves convey impulses from the CNS to the muscles, controlling their contraction.

2. Sensory fibers. These nerves carry impulses to the brain, for example, as for sight, hearing, smell, taste, touch, the state of muscle contraction, etc.

3. Mixed fibers. These nerves are a combination of both motor and sensory fibers.

You may also recall that the autonomic nervous system (ANS) is a system of nerves and isolated groups of nerve cells (called ganglia) which govern involuntary actions such as secretions of glands, movements of the intestines, pupillary reactions, etc. The ANS contains only motor fibers which synapse in ganglia before reaching the effector organ. Thus, we have preganglionic fibers which come from the CNS or other ganglia, and postganglionic fibers which run from the ganglia to the effector organ. The ANS has two divisions:

1. Sympathetic N.S. These fibers are activated by sympathin which is liberated at the nerve synapses.

2. Parasympathetic N.S. These fibers are activated by acetylcholine liberated at the synapses.

Remember that the sympathetic and parasympathetic nervous systems have antagonistic effects and thus attempt to keep the internal environment of the body in a state of constancy (homeostasis). An example of this would be the constant adjustment of pupil size according to the amount of light entering the eye at any given moment.

Nerves of the Eye

OPTIC NERVE. The optic nerve is the special nerve of the sense of sight. The optic nerve fibers are the axons of the retinal ganglion cells.

OCULOMOTOR NERVE. The motor nerve which innervates the SR, IR, MR, IO, and levator palpebrae superioris muscles. Also innervates the iris sphincter.

TROCHLEAR NERVE. The motor nerve which innervates the SO muscle.

OPHTHALMIC BRANCH OF THE TRIGEMINAL NERVE. This branch of the trigeminal nerve is sensory. It has three divisions:

1. Lacrimal branch. Supplies sensory fibers to the lacrimal gland, conjunctiva, and the skin of the eyelids around the outer canthus.

2. Frontal branch. Supplies the eyebrow, forehead, and conjunctiva.

3. Nasociliary branch. Supplies the cornea, ciliary body, iris, area of the medial canthus, and the nasal half of the conjunctiva. (The cornea is possibly the most sensitive portion of the body.)

ABDUCENT NERVE. Supplies motor fibers to the L.R. muscle.

FACIAL NERVE. This is a mixed nerve. The motor fibers innervate muscles of the face including the orbicularis oculi. The sensory fibers do not go to the eye.

Autonomic Nervous System and the Eye

The sympathetic portion of the autonomic nervous system (ANS) supplies nerves to the eye which can constrict ocular blood vessels and dilate the pupil.

The parasympathetic portion of the ANS supplies nerves to the eye which dilate ocular blood vessels and constrict the pupil.

The ANS also controls operation of the lacrimal gland and smooth muscles of the lid.

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EXERCISE 7

Answer the following questions in the spaces provided.

1. The ____________________________ nerve is a bundle of nerve fibers, or axons, from the retinal ganglion cells.

2. List the muscles of the eye and eyelid innervated by the oculomotor nerve.

3. The cornea is innervated by the nasociliary branch of the ________________________ nerve.

4. Dilation of the pupil could occur as a result of stimulation of the _______________ portion of the ANS, or by suppression of action of the _____________________________ portion of the ANS.

5. The nerves which innervate the six muscles responsible for eye movement are:

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ACTIONS AND USES OF OPHTHALMODIAGNOSTIC DRUGS

In the last section of this study guide we explained that a knowledge of the nervous system was basic to an understanding of how certain drugs work. In this section we will relate drug actions to the autonomic nervous system in general terms, and then list for you the actions and uses of the ophthalmodiagnostic drugs most commonly used in the eye clinic.

Drug Effects in Relation to the ANS

Certain drugs used in the eye clinic are called ophthalmodiagnostic drugs because they are used in the diagnosis of eye problems. However, many of these drugs have other purposes too. Most ophthalmodiagnostic drugs have an effect on the ANS and these drugs are classified as to what type of action they perform and what portion of the ANS they act upon, i.e., sympathetic or parasympathetic.

Drugs which imitate or mimic the sympathetic portion of the ANS are called sympathomimetic drugs.

Drugs which imitate or mimic the parasympathetic portion of the ANS are called parasympathomimetic drugs.

Drugs which block the sympathetic ANS are called sympatholytic drugs.

Drugs which block the parasympathetic ANS are called parasympatholytic.

An easy way to remember these is to associate "mimic" with the suffix "mimetic", and "blocks" with the suffix "lytic".

In the section on ocular nerves we explained that the sympathetic portion of the ANS acted to dilate the pupil. It follows then that a drug which "imitates" the action of the sympathetic ANS, a sympathomimetic drug, should dilate the pupil. This is true. Parasympatholytic drugs also will dilate the pupil. Parasympathomimetic drugs are used to constrict the pupil.

Drugs commonly used in the eye clinic classified according to their action on the ANS are:

SYMPATHOMIMETIC DRUGS:

Phenylephrine HCl (Neosynephrine)
Hydroxyamphetamine HBr (Paredrine)

PARASYMPATHOLYTIC DRUGS:

Tropicamide (Mydriacil)
Cyclopentolate HCl (Cyclogel)
Homatropine HBr
Atropine Sulfate

PARASYMPATHOMIMETIC DRUGS:

Pilocarpine HCl
Physostigmine Salicylate (Eserine)

SYMPATHOLYTIC DRUGS. This group of drugs is very seldom used in the eye clinic.

Actions and Uses of Common Ophthalmodiagnostic Drugs

Because ophthalmodiagnostic drugs frequently affect pupil size you should familiarize yourself with two terms relating to pupil size, i.e., "mydriasis" and "miosis". Mydriasis is the condition where the pupil is enlarged, and miosis is a constricted pupil. Some drugs are called "mydriatics", or "miotics", with respect to their action on the pupil. Some drugs produce both mydriasis and cycloplegia; these drugs are called cycloplegics. Cycloplegia is the state of the eye where the ciliary muscle of the eye is paralyzed and the eye is unable to accommodate (focus). It is possible to have mydriasis without cycloplegia (depending on the drug used), but you cannot produce cycloplegia without mydriasis. You should remember that a cycloplegic is never used when all that is desired is mydriasis of the eye.

PHENYLEPHRINE HCl (Neosynephrine), 2.5%-10%.

Actions and Uses. Mydriasis without cycloplegia. Effect lasts 2-3 hours. Also produces vasoconstriction. Phenylephrine is the drug of choice in the mydriatic group.

HYDROXYAMPHETAMINE HBr (Paredrine), 1%.

Actions and Uses. Mydriasis with little, if any cycloplegia. Also acts as a vasoconstrictor. Pupillary dilation lasts 1-2 hours.

Both Phenylephrine and Hydroxyamphetamine are mydriatics. They are frequently used when the doctor wishes to perform an ophthalmoscopic examination of the eye through an enlarged pupil.

The other group of drugs which produce pupillary dilation, but which also produce paralysis to the ciliary muscle, will be listed next. These are the cycloplegics. They are not used unless cycloplegia of the eye is desired.

TROPICAMIDE (Mydriacil), 0.5%-1%.

Actions and Uses. Produces mydriasis and cycloplegia. Onset of action is rapid (15-30 min) and its duration of action is short (30 min-4 hrs). May be used when a short-acting cycloplegia is desired for refraction of the eye.

CYCLOPENTOLATE (Cyclogel), 0.5%-2%.

Actions and Uses. Produces mydriasis and cycloplegia. Onset of action is rapid (20-30 min) and its duration of action varies from 2-24 hours. May be used for cycloplegic refractions. Cyclogel probably produces more cycloplegic effect than Tropicamide.

HOMATROPINE HBr, 1%-5%.

Actions and Uses. Produces mydriasis and cycloplegia which may last up to 72 hours. Used frequently for cycloplegic refraction of children and for treatment of various ophthalmological conditions of the eye.

ATROPINE, 0.5%-4% (usual is 1%).

Actions and Uses. Produces mydriasis and paralysis of accommodation which may last 2-3 weeks. Used mostly for refractions in small children where pronounced cycloplegia is desired by the doctor. Atropine is also used for treatment of various other ophthalmological conditions.

The last two drugs classified by their effect on the ANS are the parasympathomimetics. It is unlikely that you will use these much in the optometry clinic yourself, but many patients you will see who have abnormally high intraocular pressure (glaucoma) must use these drugs daily. So you should have a working knowledge of some of the parasympathomimetics.

PILOCARPINE HCl, usually 2%.

Actions and Uses. Produces miosis and stimulates accommodation. Used in treatment of glaucoma to increase the outflow of aqueous, thus lowering the intraocular pressure.

PHYSOSTIGMINE SALICYLATE (Eserine), (0.25%-0.50%).

Actions and Uses. Produces miosis and some spasm of accommodation. Also used to increase outflow of aqueous to lower intraocular pressure in glaucoma patients.

Another group of drugs which could be included in the category of ophthalmodiagnostic drugs, simply because they are used as an aid in performing diagnostic tests for intraocular pressure measurement, is the topical or corneal anesthetics. The anesthetics will be discussed separately in the next section of this SW.

There is much more you must learn about ophthalmic drugs, especially their side reactions and contraindications. You will gradually learn more about them in the field. In the meantime, you would be wise to remember that the judgments pertaining to drug use should be the domain of the professional personnel in your eye clinic. It will be under their guidance that you will function. As you become more knowledgeable and competent, certain responsibilities concerning the use of specific drug preparations may be delegated to you.

EXERCISE 8

Answer the following questions in the spaces provided.

1. Drugs which imitate the action of the sympathetic portion of the ANS are called ______________________________ drugs.

2. Drugs which imitate the action of the parasympathetic portion of the ANS are called ______________________________ drugs.

3. Drugs which block the action of the parasympathetic ANS are called ____________ ______________________________ drugs.

4. Parasympathomimetics will ______________________________ the pupil.

5. Miosis is the condition where pupil size is ____________________ and mydriasis is where pupil size is ______________________________.

6. The ciliary body is paralyzed by drugs which produce ______________________________.

7. List two mydriatics.

8. List the two shortest acting cycloplegics.

9. Intraocular pressure is sometimes reduced by drugs which ____________________ the pupil. By deduction, drugs which ______________________________ the pupil sometimes increase the intraocular pressure.

10. If a patient indicated to you that he has glaucoma, you would not use a drug that ______________________________ the pupil.

OPHTHALMIC TOPICAL ANESTHETICS

Topical anesthetics are used daily in the eye clinic in order to perform tests for glaucoma. There are other reasons for using topical anesthetics on the eye, but in your role as an optometry specialist you will be using anesthetics primarily to perform glaucoma screening tests with an instrument called a tonometer.

You will remember from a previous section of this SW that the cornea is probably the most sensitive portion of the body. In order to measure intraocular pressure, the tonometer is applied directly upon the cornea. Only one or two drops of an ophthalmic topical anesthetic is required to deaden the sensory nerve endings of the cornea. Onset of analgesia occurs in a matter of a minute or two in most instances and tonometry can be performed with absolutely no discomfort to the patient. Tonometry procedures will be detailed for you in a later section of this SW.

Ophthalmic topical anesthetics are frequently called corneal anesthetics. When you use a corneal anesthetic, you should be aware that *all* anesthetics are poisons. Therefore, only the minimum amount of anesthetic required to produce the desired effect is ever used.

Common Corneal Anesthetics

In order of preference, Proparacaine HCl, Benoxinate HCl, and Tetracaine HCl are three of the most commonly used anesthetics. Although you should coordinate the use of *any* anesthetic with the professional personnel in your eye clinic, at the same time you should be aware that Tetracaine is not the anesthetic of choice for tonometry. You will be using one of the corneal anesthetics during this course, so be sure to study this section closely.

PROPARACAINE (Ophthaine or Ophthetic) 0.5% solution.

Actions: A useful short-term local anesthetic which is approximately equal to Tetracaine in potency. Onset of analgesia is rapid. Duration of action is about 20 minutes.

Side reactions and contraindications: Local instillation in the eye produces no serious side effects. Transient corneal edema may occur, but this is unusual. Sensitivity to this drug is extremely rare.

Dosage: One or two drops of 0.5% solution each eye 2 minutes before tonometry is performed.

BENOXINATE (Dorsacaine) 0.4% solution.

Actions: An effective local anesthetic. Onset of analgesia is rapid. Duration of action is approximately 20 minutes.

Side reactions and contraindications: The incidence of side effects is low but there may be slight irritation following topical instillation. Mild superficial corneal edema may occur, but rarely. In patients with cardiac disease, thyroid disease, or allergies, this drug should be used with caution.

Dosage: One drop each eye approximately 2 minutes before tonometry is performed. For Schiotz tonometry use 0.4% solution. (For applanation tonometry, 0.4% solution combined with 0.25% of sodium fluorescein dye is frequently used.)

TETRACAINE (Pontocaine), 0.5% solution.

Actions: A long-acting and surface-active local anesthetic.

Side reactions and contraindications: Tetracaine causes more allergic reactions than Proparacaine or Benoxinate. Topical use produces mild irritation. Transient corneal edema may also occur. The drug is quite toxic.

Dosage: For tonometry, use one drop 0.5% solution each eye.

Additional Information

Remember that anesthetics are toxic. If they are absorbed systemically from topical application there is marked stimulation of the central nervous system which could be serious to the well-being of the patient. Caution the patient to NOT rub his eyes for at least an hour after the use of Benoxinate or Proparacaine. Remember that his cornea will be insensitive to pain and he could injure his eye while it is insensitive. Keep the patient under observation for 30 minutes and, if tonometry was performed, examine his corneae before dismissing him.

The use of a corneal anesthetic lowers the ability of the cornea to heal itself, so corneal anesthetics are not recommended to alleviate pain due to injury of the eye. A minor injury could become a dangerous ulcer.

The next section of this SW will provide you with additional information applicable to the use of corneal anesthetics or any other ophthalmic drug preparation. It will cover prevention, recognition, and disposition of drug reactions. Combine your knowledge of this section with the following section so that you will have a grasp of the "DOs" and "DON'Ts".

EXERCISE 9

Answer the following questions in the spaces provided.

1. The corneal anesthetic of choice is ______________________________ in

____________% solution.

2. All anesthetics are ______________________________, therefore, only the minimum amount required to produce the effect desired is used.

3. Systemic absorption of an excessive amount of a topical anesthetic could seriously stimulate the _________________________ _________________________

___________________________.

4. After the use of a corneal anesthetic, the patient should be cautioned to not

____

_________________________________.

5. Corneal anesthetics lower the ability of the cornea to ______________________.

PREVENTION, RECOGNITION AND DISPOSITION OF DRUG REACTIONS

When it is necessary to administer an ophthalmic drug, there are certain guidelines to follow for the benefit and safety of the patient. Having followed proper guidelines does not preclude the possibility of an unexpected drug reaction. Therefore, it is necessary to recognize a reaction and to know what to do in the event an undesirable reaction occurs.

Prevention

Probably the best prevention is to take a good case history. Inquire about any drug sensitivities the patient may have experienced. Also ask the patient if he has glaucoma or any other ocular disease.

Look closely at the drug label. Read, then re-read, the drug label to ensure that it is the proper drug to administer. Then read it a third time before administering the drug.

Check the label date. If the drug has exceeded the date on the label, don't use it--discard it and get a fresh preparation.

Be aware that some drugs come in preparations that are for use on other parts of the body. Therefore, it is important that the word "OPHTHALMIC" appears after the description or name of the drug on the drug label. Only ophthalmic quality drugs should be instilled in the eye.

Be aware of the precautionary information contained with the drug. For example, it is not advisable to use mydriatics and cycloplegics on glaucoma or preglaucoma patients; also, it is generally not a good idea to use topical anesthetics on an inflamed eye. Know the other precautions.

Know what the correct dosage is for the result desired, and then administer only the minimum dosage required.

Immediately after instillation, systemic absorption of a drug is lessened somewhat if light pressure is applied over the lacrimal sac for a few seconds. This prevents drainage of the drug into the stomach by way of the nose and throat.

Finally, be sure that you know and understand your doctor's instructions prior to the administration of the drug preparation.

Recognition

Allergic hypersensitivity is the most frequent cause of drug reactions. A reaction to a drug dose which normally would be harmless is called a hypergic reaction. These reactions may vary from moderate swelling and redness to convulsions and death. Because of the wide range of clinical pictures possible, recognition of a drug reaction would be based on the degree and type of change the patient manifests as a result of the administration of a drug.

Disposition

In case of a reaction, stop instilling the drug, recline the patient, and call a physician immediately. If a physician is not immediately available, obtain the assistance of the nurse or physician assistant until the physician arrives.

EXERCISE 10

Answer the following questions in the spaces provided.

1. Probably the best prevention of a drug reaction is a good ______________________

__________________________.

2. Before administering an eye drop, list three things on the drug label you would look for:

3. After instillation, light pressure applied to the ________________________

________________ for a few seconds helps to lessen the systemic absorption of eye drops.

4. _________________________ ______________________ is the most frequent cause of drug reactions.

5. You should not use ophthalmic preparations in the __________________________ or _________________________________ group on patients who have an elevated intraocular pressure.

INSTILLATION OF OPHTHALMIC DROPS

Most patients who are going to be "dropped" are a little nervous--they may not understand what is going on, and may be a little fearful of the procedure. Therefore, your first step will be to reassure the patient. Explain to him what you are going to do, and that it won't hurt.

Instillation of drops into the patient's eyes is a relatively simple thing to do; however, there are certain procedures to observe. Have the patient lean back in the examining chair, and adjust the headrest so the patient is facing upwards. Instruct the patient to look up. With the thumb of your left hand, pull down the skin of his lower eyelid, resting the thumb on the bony ridge under the eye. Place one drop of the ordered ophthalmic drop into the lower conjunctival sac, being careful not to let the tip of the dropper touch the eye or eyelashes. Instruct the patient to close his eyes gently. Apply light pressure over the lacrimal sac and blot the excess medication from the lids with facial tissue. Repeat for the other eye.

The conjunctival sac will hold only one drop. Thus, when an order for eye drops is written without specifying the number of drops, one drop is enough, unless it was not a "direct hit"; then a second drop should be instilled. Do not exert pressure on the eyeball. Do not allow the tip of the dropper to touch the patient. If the dropper or bottle become contaminated, discard them.

Most patients tend to blink and squinch up when the drop strikes the eye. This tends to eliminate the medication from the eye before it has had a chance to do its job. To minimize the blink and possible elimination of the medication, retain control of the lid (or lids) for a couple of seconds after instillation. It is also a good idea to let the drop strike the lower conjunctival sac slightly temporal to the cornea. This can be accomplished more easily by having the patient look to his left when dropping the right eye and to the right when dropping the left eye.

EXERCISE 11

Answer the following questions in the spaces provided.

1. Before instilling drops, you should first ______________________________ the patient.

2. The tip of the dropper should not be permitted to touch the ________________.

3. When a drop strikes a patient's eye you normally would expect him to __________ ________________________. To prevent this from eliminating the drug before it has a chance for absorption retain control of the ____________________ for a couple of seconds.

4. It is often a good idea to have the patient look to his _______________ when dropping the right eye and to his ___________________ when dropping the left eye.

Approximately two or three percent of the population over the age of 40 have glaucoma, a disease of the eye characterized by elevated pressure within the eye. Intraocular tension will be determined on all examinees who are 39 years of age and older, and in all others in whom palpation or history is suggestive of abnormal pressure. The instrument to be used is a calibrated Schiotz tonometer (Stock No. 6515-382-6100) (Figure 11). This instrument measures the depth of indentation of the cornea of the eye produced by a given force acting over a constant area. The identability of the eye is determined in part by its internal pressure, but is not identical with this pressure, nor does it vary absolutely with it. It offers, however, a very satisfactory way of judging the approximate intraocular pressure. The scale reading of the tonometer, while it rests on the eye of the examinee, is translated to calculated intraocular pressure by the use of a calibration table, and the pressure will be entered in item 69, SF 88.

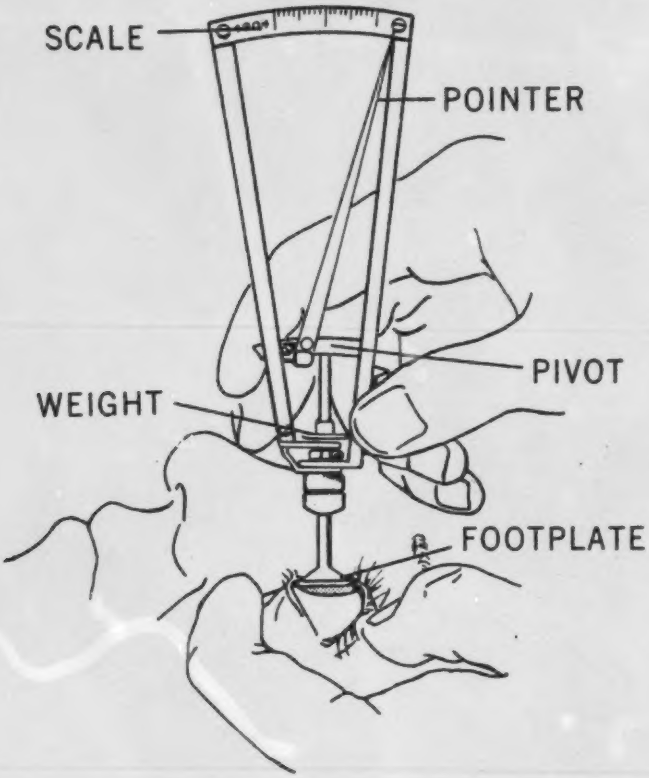

Figure 11

Technique

Tonometry should be as simple and brief as possible. A long buildup to the patient may excite him and affect the readings, as may abruptly confronting him with an instrument poised just above the eye. Lay the examinee back comfortably in such a manner that the plane of the face is parallel to the floor. Take care that the neck is not hyperextended and that there is nothing constricting the neck which would increase jugular pressure. A short-acting topical anesthetic will be used and the examinee will remain under observation for 30 minutes to ensure the absence of adverse reactions as well as foreign bodies impacted during examination.

1. Do not use tonometer on examinees suspected of having conjunctivitis.

2. Be sure that the tonometer zeroes properly on the test block which is provided with each instrument. At the same time make certain that the plunger and the needle move with perfect freedom.

3. Do not use toxic solutions for sterilization. If an ultraviolet sterilizer is not available, use aqueous benzalkonium chloride in solution no stronger than 1:5000, being careful to wipe the solution from the base plate prior to placing the instrument on the cornea.

4. Use the basic 5.5 Gm weight for the screening examination. If the scale deflection is less than four units, use a 7.5 Gm weight or more as needed to bring the deflection to 4 or greater on the scale.

5. Perform the examination promptly after instillation of the topical anesthetic.

6. The examiner's fingers should be on the bony orbital rims while holding the eyelids open. This will prevent digital pressure on the eyeball which would result in falsely high pressure readings.

7. Before placing the instrument on the eye to be examined, be sure that the patient is relaxed and that his other eye is open, and has an unobstructed view of an object which will allow constant fixation at the proper angle during the pressure determination.

8. Watch for slight smooth and regular fluctuation of the needle. This indicates that the instrument is correctly placed and is functioning well since this reflects the actual pressure pulsation within the eye.

9. When the pressure obtained is abnormal, record the plunger weight and scale reading in item 73, SF 88, in addition to the pressure reading in item 69. Glaucoma is suspected when the examinee has tensions as follows:

   a. Two or more current determinations of 22 mm Hg or higher.

   b. One or more determinations of 25 mm Hg or higher.

   c. A difference of more than 4 mm Hg between right and left eyes.

EXERCISE 12

Answer the following questions in the spaces provided.

1. Glaucoma is a disease evidenced by ____________________________ intraocular pressure.

2. The instrument used to measure intraocular pressure is the ______________________.

3. When positioning the patient for measurement of intraocular tension, check to be sure that the patient's neck is not ____.

4. To sterilize a tonometer, use either an ultraviolet sterilizer or

____________________________ __________________________ in solution no stronger than ____.

5. If the Schiotz's scale deflection is less than four units use a ________________ gram weight, but begin the examination with a ______________________ gram weight.

6. List the three intraocular tension measurement combinations which would lead you to suspect glaucoma.

THE VISUAL PATHWAY

The visual pathway is defined as the path traveled by nerve impulses between the eye and the brain when the retina is stimulated by light or sight. Although this definition is oversimplified, it gives you the basic idea of what the visual pathway is. We should understand, however, that the brain does not receive a simple copy of the retinal image. Vision is much more complex than that. When the retina of the eye is stimulated by light or by an image, an information-gathering process about the light or the image is begun. The information is organized and coded into nerve impulses, and the coded impulses are transmitted to the visual cortex of the brain by means of the visual pathway.

The visual pathway consists of seven structures: the retinae, optic nerves, optic chiasm, optic tracts, lateral geniculate bodies, optic radiations, and the visual cortical areas (Figure 12). There are three neurons which connect the visual receptors (rods and cones) of the retina to the cortical visual areas located in the occipital lobe of the brain. The first neurone is the retinal bipolar cell which connects the rods or cones to the second order neurone, the ganglion cell. The ganglion cell body is also located in the retina, but its axone extends from the retina to the optic nerve, optic chiasm, and through the optic tract to synapse in the lateral geniculate body with the third order neurone. From the lateral geniculate body (LGB) the axone of the third order neurone passes through the optic radiation to the visual cortex.

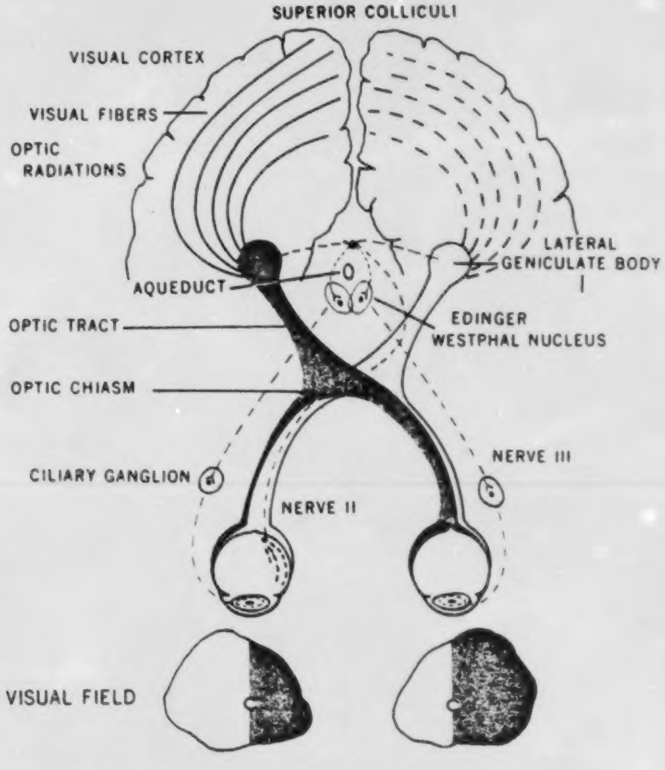
SUPERIOR COLLICULI
VISUAL CORTEX
VISUAL FIBERS
OPTIC RADIATIONS
LATERAL GENICULATE BODY
AQUEDUCT
OPTIC TRACT
EDINGER WESTPHAL NUCLEUS
OPTIC CHIASM
NERVE III
CILIARY GANGLION
NERVE II
VISUAL FIELD

Figure 12

Tied in closely with the visual pathway are return pathways between the lateral geniculate bodies and the iris of each eye. The return pathways are responsible for the function of pupil size during the act of accommodation or when the retina is stimulated by light. The LGB thus acts as a processing center for nerve impulses between the retina and higher levels of the brain.

In subsequent sections of this SW you will learn how the architecture of the visual pathway is related to the visual fields and to the pupillary reflexes.

EXERCISE 13

Answer the following questions in the spaces provided.

1. List the seven structures of the visual pathway.

2. The cell bodies of the first and second order neurones of the visual pathway are located in the ______________________________. These neurones are named

______________________________ cells and ________________________ cells.

3. LGB is an abbreviation for _______________________ _____________________

_______________________. The LGB is a processing center for nerve impulses originating in the eye and it distributes these impulses to _______________________.

4. Return pathways to the eye are responsible for transmitting nerve impulses which affect the size of the ______________________________.

5. The visual cortex is located in the ____________________________ lobe of the brain.

PUPILLARY REFLEXES

The pupillary reflex tests are objective neurological tests for integrity of the visual system (with exception of the cortical centers). Pupillary reflex tests are of importance in detecting and diagnosing the presence of cranial lesions in or near the visual pathway. It is the responsibility of the 912X5 to be able to differentiate between a normal and abnormal pupillary reflex response.

The pupillary reflexes may be divided into three responses:

1. Direct

2. Consensual

3. Accommodative

Pathway for the Direct Pupillary Reflex (Refer to Figure 12)

The direct response originates in the light-receptive cells of the retina, travels back along the optic nerve, through the semi-decussation (splitting in half) at the optic chiasm, backwards along the optic tract to the LGB (Lateral Geniculate Body). Fibers run from the LGB to the Pretectal Nucleus and the homolateral (same-sided) III Nerve Nucleus where parasympathetic fibers run along with the III Nerve to the Ciliary Ganglion. From the ciliary ganglion, fibers extend forward to the pupillary sphincter. Light entering one eye causes a reflex to follow the above path, causing the pupil of the stimulated eye to constrict.

Pathway for the Consensual Pupillary Reflex (See Figure 12)

The consensual pupillary reflex follows a similar afferent (to the brain) pathway as the direct reflex. Light entering one eye stimulates that retina, and the signal travels backwards along the optic nerve, optic chiasm, optic tract to the LGB. After synapse in the LGB, fibers run to the pretectal nucleus and then to the contralateral (opposite side) III nerve nucleus. The efferent (from the brain) fibers follow the same pathway as before. Light entering one eye causes the contralateral pupil to constrict.

Pathway for the Accommodative Pupillary Reflex (See Figure 12)

The third pupillary reflex is initiated by an accommodative stimulus (usually a blur). The impulse travels from the III Nerve nucleus, following parasympathetic fibers along the III Nerve. These fibers eventually reach the ciliary ganglia and the pupillary sphincters of each eye. When an individual looks at something at nearpoint, three things happen. The eyes converge, they accommodate (focus at nearpoint), and the pupils constrict.

The neurologist, knowing the location of the various nerves which mediate the pupillary reflex, can effectively localize the position of various lesions which may affect these pathways.

ER- 76-569

Test for Direct Pupillary Reflex

The optometric technician should know how to determine and record the pupillary reflex in the proper manner. In eliciting the direct reflex, room lighting should be even. The examiner will occlude the eye not being tested, he will then shine a penlight into the eye being tested. That pupil should constrict markedly. After noting the rate and symmetry of constriction, the examiner should turn the light off. The pupil should dilate or expand almost immediately. This test is then repeated for the opposite eye.

Test for Consensual Pupillary Reflex

In performing the test for determination of the consensual reflex, the procedure is similar. Again, room lighting should be even. One eye should be shielded from the penlight, but not from the examiner's view. The examiner then shines his penlight into the eye which is not occluded while observing the eye which is shielded. The pupil of the shielded eye should constrict slightly when light is shone into the non-shielded eye. After determining the reflex for one eye, the process should be repeated for the other eye. With practice, both the direct and consensual reflexes can be elicited, observed and recorded at the same time.

Test for Accommodative Pupillary Reflex

The accommodative or nearpoint reflex is again tested in an evenly lighted room. Both eyes are open for this test. The patient is instructed to look from an object located at farpoint to an object located at nearpoint. The pupils should constrict when the patient looks up close. If the nearpoint object consists of fine letters, and if this object is gradually brought closer to the eyes, both pupils should constrict a greater amount as the target is brought closer.

When observing the pupillary reflexes, the constriction of the pupils should be balanced. In the direct response, each pupil should constrict at the same speed, should remain round, and should start and stop with the pupil sizes equal. There should also be an equality in the consensual pupillary reflex. When observing the accommodative reflex, both pupils should constrict equally and simultaneously.

Recording the Pupillary Reflex Tests

The pupillary reflex tests may be recorded on SF 88 (Item 26) as PERRLA (Pupils are equal in size, round, and react to light and accommodation) if the responses are normal. If the responses are abnormal, record the abnormality and notify the doctor. The same method may be used on any local form used in the clinic.

EXERCISE 14

Answer the following questions in the spaces provided.

1. List the three types of pupillary reflexes.

2. What abbreviation is used to indicate normal pupillary reflexes? ______________

3. An afferent nerve fiber is one which carries nerve impulses __________________ the brain. An efferent nerve fiber carries nerve impulses ________________ the brain.

4. The afferent pathway for the pupillary reflex (to light) is the same as the afferent pathway for vision up to what structure? ____________________________

____

5. Nerve impulses to the pupillary sphincter of the iris are transmitted by

________________________________ fibers of the III Nerve.

THE VISUAL FIELD

The ability to see and identify an object depends in part upon the region of the retina which is stimulated by the image of an object, and the continuity of the neural pathways which connect the retina to the visual centers located in the occipital area of the brain. Any lesion in or near these visual pathways causes a decrease or absence of vision in that portion of the visual field which is transmitted by the affected pathway. One of the responsibilities of the optometry technician is to measure the extent of the visual field.

Definition

The term "visual field" as used here, is defined as that part of space that can be seen when the head and eyes are motionless. The visual field in normal two-eyed vision is the binocular field. The field of a single eye is the monocular or uniocular field.

Positions in the Visual Field

When a person is looking directly at a point, he is using his foveal or central vision. He is said to be fixating that point, and the point may be considered a fixation point. The fixation point lies on the visual axis or line of sight, this point and any other object on the visual axis appears at the exact center of the visual field. The direction from the center of a visual field is often given as superior (up), inferior (down), nasal and temporal. Nasal refers to the half of the visual field toward the viewer's nose, and temporal to the half toward the viewer's temple. This pertains to the monocular field only. Obviously, the nasal half of the field is to the right in the left eye, and to the left in the right eye, and the temporal half is to the left in the left eye and to the right in the right eye.

The terms nasal and temporal are also used to describe positions on the retina of the eye. The temporal retina is the side toward the temple, and the nasal retina is the side toward the nose. Note, however, that an object in the nasal field will be imaged on the temporal retina, and an object in the temporal field will be imaged on the nasal retina because light rays cross the visual axis.

Relationship of Visual Pathway Structures to the Visual Fields

RETINA. As has been noted previously, the retina consists of 10 layers. The sensory cells in the retina are called rods or cones depending on their shape and function. Light entering one side of the eye is refracted to the opposite side of the retina. This explains how images located in the temporal field are imaged on the nasal retina. In the same manner, if a defect is located in the nasal retina or any of the nerves supplying the nasal retina, the image of this defect or the result of this defect will be projected to the temporal visual field. (See Figure 13)

Visual performance varies with the location of the image on the retina, and hence with the location of the object in the visual field. Therefore, in measuring certain visual functions, the light or object being used for the test must be placed a known distance from the visual axis.

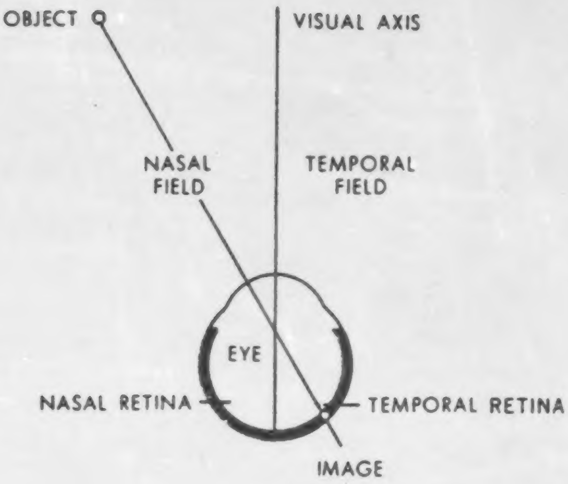
OBJECT
VISUAL AXIS
NASAL FIELD
TEMPORAL FIELD
EYE
NASAL RETINA
TEMPORAL RETINA
IMAGE

Figure 13

When tests of visual performance in various parts of the visual field are made, it is usually found that the ability to perform a certain task--the ability to see a certain sized target (visual acuity)--decreases with distance from the center of the visual field. If all the points at which a minimum or threshold level of performance is attained are plotted on a chart of the visual field, they form a ring (usually rather irregular) around the center of vision. If points are similarly plotted for successively higher levels of performance the result is a series of roughly concentric rings. For visual acuity, the ability to discern detail, such lines of equal performance are called isopters. (See Figure 14)

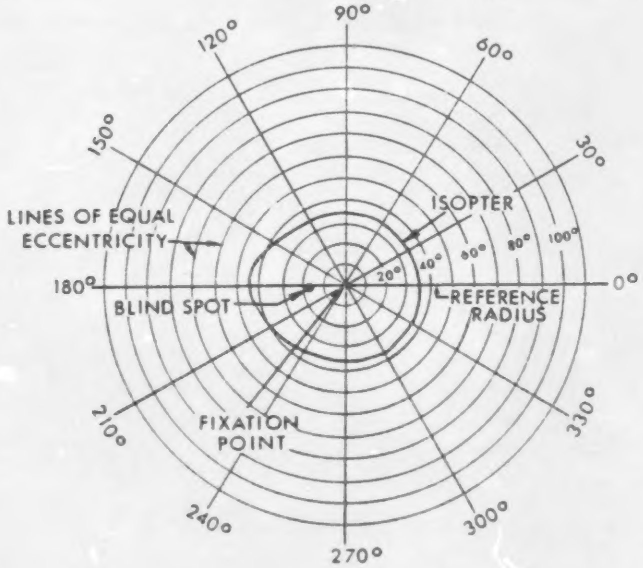
90°
120°
60°
150°
30°
ISOPTER
LINES OF EQUAL ECCENTRICITY
180°
0°
20°
40°
60°
80°
100°
BLIND SPOT
REFERENCE RADIUS
210°
330°
FIXATION POINT
240°
300°
270°

Figure 14

As explained in the anatomy of the retina, the optic disc contains no receptive cells, therefore no light or vision is mediated in the area of the optic disc. Since the optic disc is located in the nasal portion of the retina, the blind spot or physiological scotoma caused by the absence of light-sensing cells will be located in the temporal visual field. Usually a lesion affecting the retina causes a positive scotoma (black blind spot), and a lesion affecting the posterior portions of the visual path causes a negative scotoma (absence of vision). The physiological scotoma, however, is a negative scotoma. The presence of the blind spot can be demonstrated by closing your left eye and looking at the cross in Figure 15. By slowly moving the study guide from arms length to an area about a foot from your eyes, you will notice that the circle will disappear. This is due to the fact that the image of the circle falls on the blind spot (optic nerve head), and therefore cannot be seen.

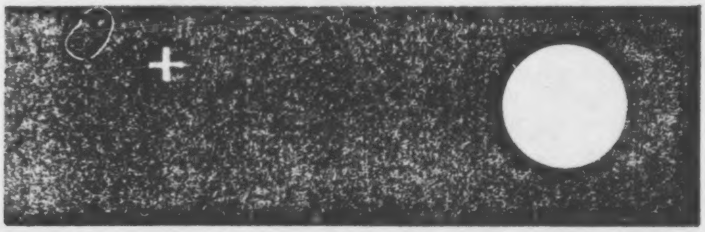

Figure 15

THE OPTIC NERVE. (Figure 12). The optic nerve is composed of bundles of axones of ganglion cells leaving the eye and entering the brain. It is approximately 5 cm long. The general topographical relationships are upheld in the arrangement of the nerve fibers in the optic nerve. This topographical arrangement is maintained fairly consistently throughout the visual system.

THE OPTIC CHIASM. (Figure 12). At the optic chiasm, the ganglion cell axons undergo a semi-decussation, or semi-splitting. Fibers from the temporal retina (nasal visual field) pass directly back to the brain. Fibers from the nasal retina (temporal visual field) cross over to the opposite side of the brain.

OPTIC TRACTS. (Figure 12). Extending further into the brain from the optic chiasm are continuations of the ganglion cells, each side mediating either the right or left visual field. These continuations are called the optic tracts.

THE LATERAL GENICULATE BODY (LGB). (Figure 12). The optic tracts synapse deep in the brain at the LGBs. This is the main relay station for visual sensations. The pupillary reflex pathway branches from the main bundle of visual fibers at this point.

OPTIC RADIATIONS. (Figure 12). Extending back from the LGBs are the third order neurons called optic radiations. These neurons connect the LGB to the visual cortex.

VISUAL CORTEX. (Figure 12). The vision area of the brain is located in the region of the occipital lobes (Broadmann's areas 17, 18 and 19). This portion of the brain is not only associated with seeing, but with remembering things seen in the past, recognizing things seen at the present time, and associating memories of things seen with things being seen.

As you can see from the above, a lesion affecting any of the nerve fibers within the seven structures along the visual pathway would produce a defect in all or a portion of the visual field; and, of course, the shape or extent of the visual field defect would depend on the size and location of the lesion within the visual pathway. Knowing the nerve fiber distribution along the pathway and by careful analysis of visual field plottings, it is often possible for the doctor to closely approximate the location of a lesion within the brain.

Visual Field Defects

We have already defined positive and negative scotoma and physiological scotoma. Scotomas are blind areas (or areas of reduced vision) within the visual field which do not extend to the periphery of the field. Usually the field around a scotoma is normal.

Defects of the limits of the field may occur as a constriction of all the field, constriction in one meridian only (field distortion), or constriction in a segment (sector defect), or a quadrant (quadrantanopsia), or half of the field (hemianopsia).

PERIPHERAL VISUAL FIELD METHODS

There are many methods of determining the extent of the visual fields, the first and easiest to administer is the confrontation test. The confrontation test is based upon a comparison of the monocular fields of vision of examiner and examinee, which, assuming their facial conformations to be alike should be similar. The examiner will face the examinee at a distance of 2 feet. One or the other flexes his knees or rises on his toes so as to bring their heads to the same horizontal level. Each holds his head normally erect. The examinee closes his left eye with gentle pressure of the little finger and fixes his right eye upon the examiner's left eye. The latter closes his right eye and fixes his left upon the examinee's open eye. This fixation is continued throughout the test of the examinee's right eye. The examiner holds a plain white 1 cm. sphere on a wire handle overhead and in a plane midway between the two. He lowers the sphere keeping his hand out of the way, until it is seen by the examinee. Assuming similar brow conformation, the examiner and the examinee should see the sphere simultaneously. The superotemporal, superonasal, nasal, inferonasal, and inferior limits of the field of vision are similarly compared. To estimate the examinee's temporal and inferotemporal limits of vision, the sphere is held behind the plane of the examinee's eye and brought forward until visible; in these meridians the visual field normally extends to 90° or more. A similar technique is used to test the left eye.

If on the confrontation test the field of vision appears to be constricted to a degree not attributable to prominent nose or brow, or if for any other reason the examiner suspects a visual field defect, a more exact perimetric study is made, employing the perimeter and tangent screen.

The average visual field for form is approximately 90° temporal, 62° superotemporal, 52° superior, 55° superonasal, 60° nasal, 55° inferonasal, 70° inferior, and 85° inferotemporal.

The Perimeter

The first perimeter was built in 1857 by Aubert and Forster. Almost all the changes which have taken place since then have been improvements in illumination and automation. The basic technique remains the same. There are several types of perimeters in use today, hand or portable perimeters, Ferree-Rand and Brombach perimeters, arc projection perimeters, and hemispherical projection perimeters. The perimeter most widely used in the USAF today is the Brombach Perimeter (Perimeter, Ophthalmological, FSN 6515 355 0650; Chart, recording, perimeter FSN 6515 355 0680 (right) and 6515 355 0670 (left). It resembles an arc with the patient's eye as its center. An adjustable light source is provided to illuminate the arc equally at all points. A head and chin rest is provided to maintain proper positioning of the patient's head. The perimeter is designed to examine peripheral visual fields, but a campimeter attachment may be used to test central fields. The radius of the arc is 33 cm, this is equal to the test distance from the patient's eye. Normally, 7 Ft-C of illumination will be used with this instrument.

The technique of examining visual fields with the perimeter is as follows:

1. Complete identification data on perimetry record chart. Note that there are two charts, one for each eye. Don't forget to include test target data (usually 3 mm White) and the date of the examination.

2. Place right chart in clip provided on back of perimeter.

3. Occlude patient's left eye with FSN 6515 367 0420 Shield, Eye, Surgical, Plastic.

4. Seat patient comfortably in front of perimeter and place his head in the left side of the chin rest.

5. Instruct patient to observe yellow fixation point at all times. He should not move his eyes from the fixation point. The examiner will insure this by observing the patient's eyes during the examination.

6. While observing the fixation point, the patient should indicate when he becomes aware of the test object in his peripheral field. The test object should be shown to the patient at this time. Usually a signal system is arranged so that the patient does not speak during the examination (one rap with a coin on the perimeter table indicates appearance of the test object, while two raps indicate its disappearance).

7. Demonstrate the movement of the test object from the periphery to the central area.

8. To test the peripheral visual fields of the patient, place the arc in the horizontal position, and slowly move the test object from the extreme temporal region toward fixation. Mentally note the position where the patient reports visibility of the object. Continue moving the object toward fixation to detect any scotomata. Mark chart with a dot at the position which patient reported detection of test object.

9. After the temporal field has been investigated, move the test object to the extreme nasal meridian and test the nasal field, marking the chart as before.

10. Unlock the arc and rotate it to the 45°-225° position (as measured from the examiner's right). Lock arc.

11. Plot the superior temporal and inferior nasal fields in the same manner as you plotted the horizontal fields.

12. Unlock arc and rotate it to the vertical position.

13. Plot the superior and inferior fields.

14. Unlock arc and rotate it to the 135°-315° position.

15. Plot the superior nasal and inferior temporal fields.

16. Remove the right chart and replace it with the left.

17. Move occluder to patient's right eye.

18. Position patient's chin in right half of chinrest.

19. Repeat steps 8 through 14, testing the patient's left eye.

20. When test is completed, turn instrument off, remove occluder and charts.

21. Before presenting the charts to the doctor outline the peripheral visual fields of each eye by connecting the dots with straight lines. These lines are called ISOPTERS, and represent the threshold of vision for the size and color target used.

22. Attach the perimeter charts to the basic eye examination form used in your clinic (or to the referral form, if used), and present them to the doctor.

The perimeter should be kept clean at all times. The dust cover should be used when the perimeter is not in use.

CENTRAL VISUAL FIELD METHODS

The Tangent Screen

The tangent screen consists of a dull black felt cloth, usually about 2 meters square, either fixed to the wall or suspended from rollers (FSN 6515 361 0690, Tangent Screen, Folding; FSN 6515 381 0700, Tangent Screen, Roller). A white button is affixed to the center of the screen as a fixation point. The tangent screen is used to detect abnormalities in the central visual field (up to about 30°). Test distance is either 1 or 2 meters. Markings on the tangent screen include circles every 5° (for IM test distance) and radial lines every 15°. The lines and circles help to localize the test object when recording on the tangent screen chart (usually locally reproduced). The blind spot is also indicated on most tangent screens.

Test procedure is as follows:

1. Complete identification data on tangent screen chart. Indicate which eye is being tested. Since the tangent screen tests central visual fields, the visual acuity should be recorded. The test distance (usually 1 M), test object color (usually white), size of test object (usually 2 mm) and illumination (usually about 10 ft-c) are also recorded. The patient should have any errors of refraction corrected for the test distance.

2. Occlude the patient's (poorer eye if there is a difference in vision) (left eye if vision is equal) with plastic shield.

3. Seat patient on stool so that fixation point and eyes are on the same horizontal plane. A 1 M thread attached to the tangent screen will facilitate positioning.

4. Instruct patient to observe fixation button at all times. Tell him that you will move a white pin (show him the target) around in his field of view, and that he is to report appearance and/or disappearance of the pin (a signal system may be used). The examiner should insure that the patient does not move his eyes from the fixation spot.

5. Demonstrate the appearance and disappearance of the target by slowly passing it through the blind spot. Reassure patient that disappearance of the target is normal. Repeat demonstration until you are assured that patient can accurately report disappearance and appearance of target.

6. Begin testing the patient by measuring the blind spot, always moving the target from a non-seeing area to a seeing one. Insert a black-headed maptack or pin at the points where the patient reports visibility of the test object. Test eight meridia to outline blind spot.

7. Test remainder of field by moving test target inwards from periphery along the radial lines. If a scotoma is found, stop and plot it from non-seeing to seeing areas. Occasionally test one of the circular lines so that all of the field is tested. Another standard practice is to place a pin on the felt where the patient first reports visibility of the test target as you move it inwards from the periphery.

8. When the entire central field has been tested with the 2 mm W target, the central field or any suspicious areas may be tested with a 1 mm W target.

9. Transfer the findings from the tangent screen to the record chart.

10. Change the occluder to the patient's right eye.

11. Repeat steps 5 through 9.

12. Connect all dots indicating equal isopters.

13. Present the chart to the doctor.

The Harrington-Flocks Tachistoscope

The Harrington-Flocks tachistoscope (FSN 6515 562 0444; Tachistoscope, Visual Field Test) is a rapid simple screening test for relatively prominent visual field defects. This instrument consists of a series of large test cards printed with fluorescent ink, and a stand with chin rest, card holder and UV light source. Each test card has a series of different patterns of dots which are made visible only under ultraviolet radiation, and a black spot used as a fixation point. The UV lamp may be left on for demonstration purposes or flashed in 1/4-second bursts for testing. Room illumination should be 5 ft-c. Central fields (25°) are tested.

Test procedures are as follows:

1. Complete identification data on record chart. One chart is to be used for both eyes.

2. Occlude patient's left eye.

3. Seat patient comfortably in chair or on stool, and place his chin in the chinrest. Turn toggle switch on.

4. Instruct patient to observe black fixation dot at all times. Tell him that the test consists of observing the white card and reporting the number of dots that he sees. Demonstrate, leaving the light on for a few seconds.

5. Expose second test card and depress flasher button. The patient should report seeing three dots. If he reports seeing the cross, move his head forward or backward, flashing after each adjustment until the cross disappears.

6. Change to third card and flash light. Continue changing cards and flashing the light until the patient makes an error. If an error is made (i.e., patient reports three dots when there are four, or reports visibility of small crosses, or does not report visibility of large crosses) flash the light once more. If the error is repeated, have the patient indicate or describe what he saw. Cross out the "unseen" dot on the composite test chart.

7. Change occluder to right eye and repeat steps 5 and 6, reminding the patient to maintain fixation on the black dot.

8. If any dots are not seen, a further investigation with the aid of the tangent screen is indicated.

9. Attach composite record chart to referral or basic form and submit to doctor.

The Auto-Plot Tangent Screen

The Auto-Plot tangent screen is a recently stock-listed automated method of testing central fields. It has a range of about 27°, which is equivalent to a 1 - M tangent screen. Components include a chin rest, alignment device, target projection system and field recording system. Various sizes as well as various color test targets may be presented. The test target is opto-mechanically connected to the recording device.

Test procedure is as follows:

1. Complete identification data on record chart. One chart may be used for both eyes if the respective isopters are properly annotated. Insert chart in instrument.

2. Occlude patient's left eye.

3. Seat patient comfortably and place his chin in the chinrest. Raise the eye alignment ring and adjust the chin height and fixation spot so the spot is visible in the center of the ring. The ring should be 38 inches from the screen.

   Turn instrument ON. Flip alignment ring down.

4. Instruct the patient to observe the "doughnut" or cross-shaped fixation target at all times. Instruct him to signal when the test spot of light disappears. Demonstrate this disappearance by moving the test spot into the blind spot or by passing the flicker switch.

5. Outline the blind spot in the same manner as with the tangent screen. Record your findings by pressing the pencil marking device onto the record chart at the appropriate places. Remember to turn the test spot off (press the flicker button) while marking the chart.

6. Plot the limits of the central field and the pie-shaped intermediate areas as on a tangent screen.

7. Investigate any scotoma as you would using the tangent screen.

8. Change occluder to the right eye and perform steps 3 to 7 again. Use either a different chart or a different color marking pencil to delineate the fields.

9. Sign and date the chart, attach it to the referral or basic form, and submit it to the doctor.

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EXERCISE 15

Answer the following questions in the spaces provided.

1. The field of vision for one eye is called the ____________________ field, while the two-eyed field is called the ____________________ field.

2. If you are looking directly at an object, this object falls in the ____________________ field; an object seen "out of the corner of your eye" falls in the ____________________ field.

3. The right retina corresponds to the (right) (left) visual field; the inferior retina corresponds to the (superior) (inferior) visual field.

4. Many optic nerve fibers cross over or decussate in the optic chiasm. The nasal retinas of both eyes are represented in (one) (both) optic tracts.

5. Look at Figure 12. If a lesion severed the right optic tract, which portion of both retinas would be affected? Draw a picture of the resultant binocular visual field.

6. Define "isopter".

7. What is a negative scotoma?

8. What is a positive scotoma?

9. Name the basic instrumentation used in each of the following tests:

   a. Confrontation

   b. Peripheral visual fields

   c. Central visual fields

   d. Central visual fields screening

10. At what distances are the following tests taken? Which test yields the greatest magnification?

    a. Confrontation

    b. Peripheral visual fields

    c. Central visual fields

11. When performing visual field tests, which eye do you usually test first? Which eye is tested first if the patient has amblyopia in one eye?

12. A visual field defect in the temporal halves of both visual fields would be called a bitemporal ______________________________________.

Department of Biomedical Sciences
School of Health Care Sciences, USAF
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SW 3ABR91235-II-3
August 1974

VISUAL ACUITY

OBJECTIVES

This Study Guide and Workbook is designed to give you basic knowledge in the following areas:

1. Visual acuity
2. Ametropia
3. Measuring and recording visual acuity
4. Screening for amblyopia or ametropia
5. Amplitude of accommodation and presbyopia
6. Measuring amplitude of accommodation
7. Cues of depth perception
8. Determining clinical depth perception (stereopsis)
9. Characteristics and anomalies of color vision
10. Color vision testing

INFORMATION

One of the duties of an optometry specialist or technician is the taking and recording of the visual acuities of patients entering the eye clinic. In order to do this properly, you must know the definition of visual acuity, the types of acuities, and some of the conditions which may affect visual acuity. You should also know that there is a distinction between visual acuity and visual efficiency.

Definition and Type of Visual Acuity

Visual acuity is a measure of the resolving power of the visual apparatus; it is a measure of the faculty of receiving, transmitting, and interpreting the retinal image.

MINIMUM VISIBLE. This is perhaps the most basic kind of acuity--one can either see a target or one can't. The minimum visible angle for a point target is between 10 and 30 seconds of arc.

SP 10-207

MINIMUM SEPARABLE. This is the least distance (expressed in minutes of arc) by which two point targets must be separated in order to be seen as two instead of one. This distance subtends an angle of about 1 minute of arc.

VERNIER ACUITY. This is a measure of the ability to distinguish a break (lateral displacement) in an otherwise straight line. It is a very sensitive type of acuity normally subtending an angle of 2 to 12 seconds of arc.

FORM VISION. Routine visual acuity tests in the eye clinic are usually form vision tests. Form vision includes detection, discrimination, and recognition of the letter or object being used as a test target. Sometimes the clinical test is called minimum visual angle, because it is measured by noting the angular separation (in minutes) of the components of the test letter or pattern. The reciprocal of this angle indicates the routine VA (visual acuity) measurement.

Clinical visual acuity is recorded in the form: 20/X where 20 is the test distance, in feet, and X represents the smallest line that the patient can read. 20/20 means that the patient can read the "20 ft" letter at a distance of 20 feet. The fraction 20/20 may be reduced to the whole number 1. The "20 foot" letter happens to subtend 5' of arc at the eye. If the letter is divided into its components, each component subtends 1' of arc. 20/20 = 1 = 1' of arc. (See Figure 16).

If the patient has poorer than average VA, 20/40 for example, he can read the "40 foot" letter at 20 feet, or in other words, he sees at 20 feet what an individual with 20/20 sees at 40 feet. The reciprocal of 20/40 is 2, and each component of the 20/40 letter subtends 2 minutes of arc at the eye. It is twice as large as the 20/20 letter.

A patient with better than average vision, 20/10 for example, can read the "10 foot" letter at 20 feet. He can see at 20 feet what the average person with 20/20 sees at 10 feet. The reciprocal of 20/10 is .5, and the components of the 20/10 line subtend .5' (30") of arc at the eye.

Sometimes a test distance other than 20 feet is used. To compensate for this, special charts may be used with letters half the size of the standard chart (if the test distance is 10 feet). If the patient can read the "average" line on this chart, his actual acuity is 10/10 which is equivalent to 20/20 (the reciprocal of each is 1). Visual acuity for far tests are always recorded with 20 as the numerator, even if the test room is less than that distance. If the patient's vision is so bad that he must change the viewing distance in a normal 20 foot room, the acuity is recorded as the viewing distance (numerator) over the test letter size (denominator). For instance, if an ambylopic patient (patient with uncorrectable poor vision) who is tested in your eye lane cannot see the 20/400 E on the Snellen Chart, have him approach the chart until he can read the letter. Record his acuity as the test distance (numerator) over the test letter (denominator); example: 8/400.

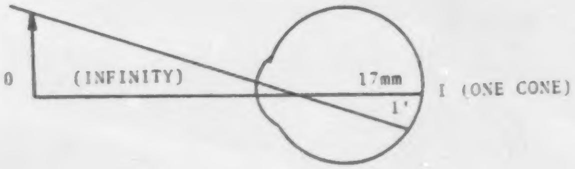
Sometimes, people who have been examined in Britain or other European countries have their acuities recorded as 6/6. This means that the test distance was 6 meters, and the patient could read the 6 meter letter. 6/6 is equivalent to 20/20. 6/3 is equivalent to 20/10 and 6/12 is equivalent to 20/40, etc.

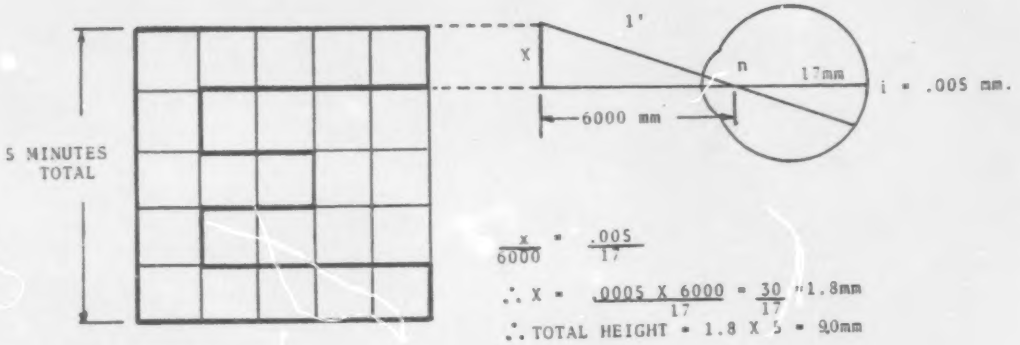
$\text{TANGENT } \angle 1' = \frac{I}{17\text{mm}}$

(TAN. ∠ 1' IS OBTAINED FROM TABLES)

$I = 17 \times \text{TAN. } \angle 1'$

$I = .005\text{mm}$ (SIZE OF CONE)





$$\frac{x}{6000} = \frac{.005}{17}$$

$$\therefore X = \frac{.0005 \times 6000}{17} = \frac{30}{17} = 1.8\text{mm}$$

$$\therefore \text{TOTAL HEIGHT} = 1.8 \times 5 = 9.0\text{mm}$$

Figure 16

Sometimes nearpoint acuities are recorded with 14 as the numerator, this means that the test distance is 14 inches. 14/14 is equivalent to 20/20, 14/7 is equivalent to 20/10 and 14/28 is equivalent to 20/40.

Remember - clinical VA is recorded as the reciprocal of the angular separation of the components of the test letter. All letters are assumed to have five components (as in Figure 16). If the angular separation of these components is 1 minute, the VA may be 14/14, 10/10, 20/20 or 6/6 depending on the test distance.

If the patient is a child or otherwise illiterate, the Landolt C test is used. The break in the C is equivalent to one component, and subtends the measurable angle of arc at the eye.

If the patient cannot see any letters on the chart, Finger Vision (F.V.) is used. The patient is asked to identify the number of fingers held up by the examiner at a particular test distance. Acuity is recorded as F.V. (test distance), example: F.V. 5 ft means that the patient correctly counted fingers at 5 feet.

If the patient cannot see fingers at a reasonable test distance, light localization is used. The patient is asked to point to a light source in an otherwise darkened room. Record as L.L.

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If the patient cannot identify the direction of a light source, light perception (L.P.) is tested. The patient is asked to state when the room lights are on or off. Record as "L.P. only" if the patient can detect the light.

NIGHT VISION. Night vision is the ability to detect, recognize, or resolve targets under low illumination. Nyctalopia (night blindness) is a general term which describes poor night vision.

Factors Influencing Visual Acuity

As can be imagined, there are many factors which can influence the visual acuity of an individual. Among these are: region of the retina stimulated, illumination, spectral quality of the light, contrast, pupil size, time of exposure, age of the patient, condition of the ocular media, individual variations, and the presence of ametropias.

REGION OF THE RETINA STIMULATED. The fovea centralis is the retinal area of keenest vision. If we assume a relative visual acuity of 1.0 at the fovea, at 3 degrees from the fovea, the V.A. drops to 0.5; at 5 degrees it is 0.3; at 10 degrees it is 0.2; and at 20 degrees, only 0.1. Figure 17 shows a graphical representation of how the relative VA drops off from fovea to peripheral retina. Figure 18 shows a graph of the distribution of the retinal receptors. Note in Figure 18 how closely the distribution of cones in the retina parallels the relative visual acuity curve of Figure 17, i.e., relative VA increases almost in exact proportion to the number of cones.

ILLUMINATION. The eye is not a photographic plate; the intensity of a visual sensation depends not on the total amount of light transferred to the eye over a period of time, but on the rate of transfer beyond a critical minimum duration. Therefore, magnitudes of light in photometry are given in terms of luminous flux, the time rate of flow of light. An example of this may be given in comparing a candle to a flashbulb. The flashbulb is obviously brighter than a candle, but the duration of the flash may be only 1/25 of a second. The candle, although dimmer, may burn for hours, thus giving a greater "amount" of light, but spread over a longer time. The Lambert is the unit of measurement for luminance. The visual sensation of brightness is related to the luminance of the source.

You remember that cones function in bright light and rods are used in dim light (photopic and scotopic vision). Since the scotopic system has a poorer resolving power than the photopic system, visual acuity is poorer under dim light (other factors, such as reduced contrast also play a part). You will note in Figure 17 that the highest number of rods per area of retina exist just outside the foveal area. Under poor illumination (scotopic conditions), vision is better just off the fovea. For example, a very dim star in a dark sky can be seen or not seen depending on whether you are looking just a little to one side of it or directly at it. If it is a very dim star it will actually disappear if you try to look directly at it. Figure 19 shows the type of receptor in use under various conditions of luminance.

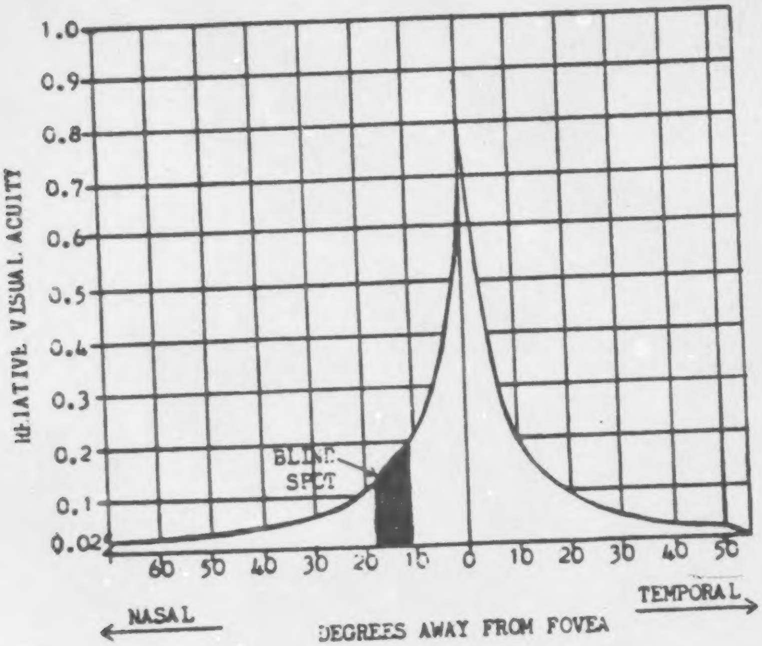


Figure 17

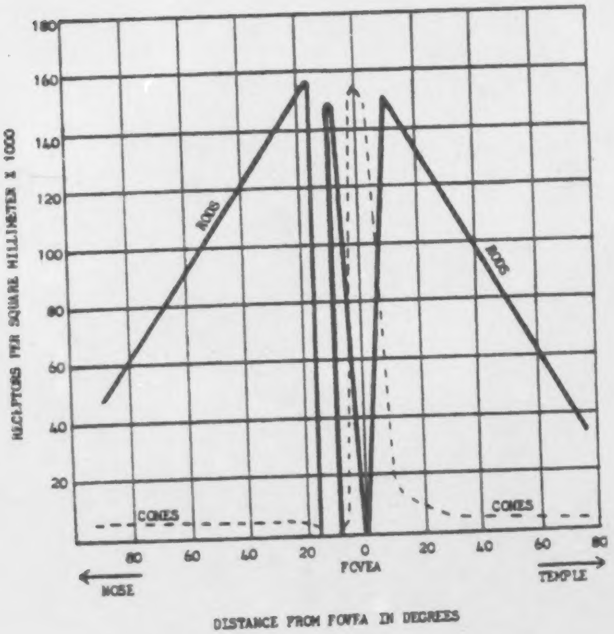


Figure 18

SPECTRAL QUALITY OF THE LIGHT. The spectral quality of light refers to its color (or wavelength). The cones are most sensitive to light of 555 mu which is close to yellow. For example, acuity tests made with monochromatic yellow light usually give a minimum visual angle of 46 seconds of arc, while those made with white light give 56 seconds of arc. The relationship between acuity and color is yellow, white, red, green, and blue.

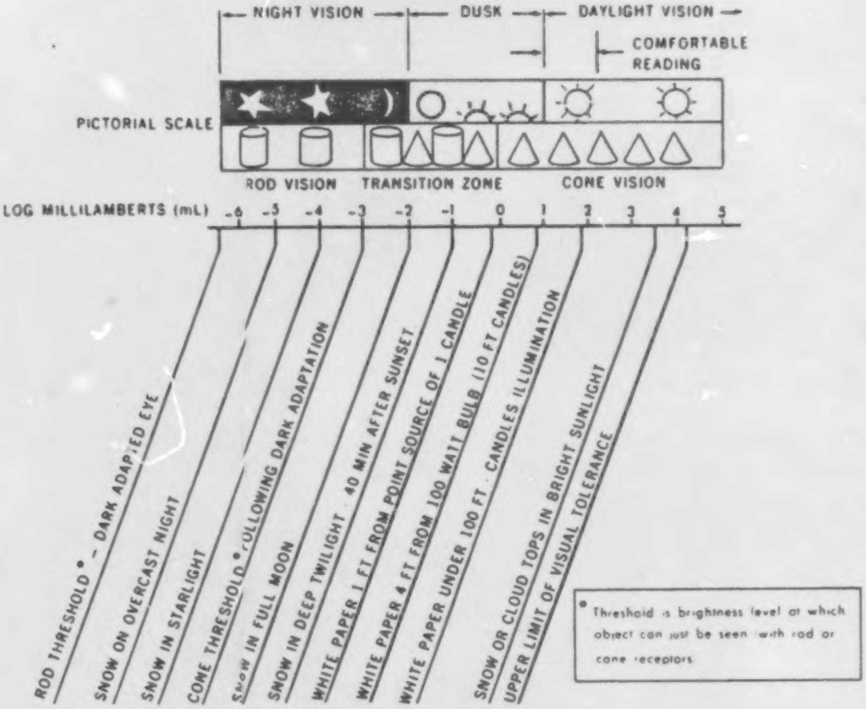


Figure 19

CONTRAST. A black letter on a white background is easier to see than a black letter on a grey background. For a given intensity of illumination, visual acuity decreases as the contrast decreases.

PUPIL SIZE. The eye has aberrations similar to the aberrations found in lenses. With large pupils, aberrations caused by peripheral rays of light tend to reduce VA; a small pupil eliminates some of the aberrations. However, if the pupil is too small, the amount of light entering the eye is diminished reducing VA, and the diffraction of light increases also reducing VA. Under average light conditions, a pupil of 2 to 3 millimeters is considered optimal.

TIME OF EXPOSURE. As might be expected, if the duration of exposure to the target is very short, VA often will be less than if the exposure were longer.

AGE. Visual acuity declines somewhat with age. Acuity is probably at its maximum between the ages of 15 to 20.

CONDITION OF THE OCULAR MEDIA. Any abnormality of the ocular media (e.g., corneal scarring, cataracts, etc.) will tend to reduce VA.

INDIVIDUAL VARIATIONS. This refers to the ability of the nervous system to be stimulated and to transmit the impulses.

PRESENCE OF AMETROPIAS. Any refractive condition of the eye which would prevent light rays entering the eye from focusing clearly would reduce visual acuity. Ametropia is any refractive error such as astigmatism, myopia, or hyperopia. (The ametropias will be discussed more fully later.) Some patients can overcome or compensate for a part of their refractive error by "straining" their eyes and thus retain normal 20/20 visual acuity without spectacles even though they normally wear spectacles constantly. Other patients can attain better vision by squinting their eyes (narrowing the palpebral fissures). Squinting the lids together produces an effect similar to that produced by small pupils. It is important to realize, therefore, that it is not possible to make a statement to the patient that he either does or does not need spectacles based solely on the results of a visual acuity test.

Visual Acuity and Visual Efficiency

We have defined visual acuity, but what is visual efficiency? Visual efficiency is the degree of perfection with which the entire visual apparatus functions; or more simply stated, it is the ability to perform visual tasks easily and comfortably. To some extent visual acuity and visual efficiency are related, but as an optometric technician it is important to understand that they are different. Visual acuity can be thought of more in terms of what the patient is capable of seeing, and visual efficiency can be thought of more in terms of whether what the patient is capable of seeing is done with ease--or with difficulty.

EXERCISE 16

Answer the following questions in the spaces provided.

1. A 20/20 letter subtends what angle at the eye? ______________________________
Each component of a 20/20 letter subtends an angle of ____________________________

_______________________ at the eye.

2. Each component of a 20/20 letter subtends an angle of ______________________
minutes of arc at the eye. This is called the ______________________________

______________________________ angle of that letter. The overall size of the 20/60 letter subtends an angle of ______________________________ minutes of arc.

3. If a patient is unable to see the largest letter on the visual acuity test chart at 20 feet, following correct clinical procedures, list in proper order the next four procedures you might have to employ in order to measure that patient's visual acuity.

4. If you permit a patient to squint his eyes (i.e., narrow his palpebral fissures) during the visual acuity test, will this give him better or worse results on the test? ____________________________________

5. An examination room measures 13 feet long. The distance between the patient and the visual acuity test chart is 10 feet. A patient can read the 20 foot line of letters. Using 20 as the numerator of the fraction, what is the patient's VA? ________ 20/________________________

6. Is scotopic vision better on the fovea or slightly off the fovea?

______________________________________ Is photopic vision better on the fovea or slightly off the fovea? ____ In each case, why?

7. A patient has O.D. 20/20 and O.S. 20/20 and has never worn spectacles. With no other available information, select the proper answer below:

a. You can tell the patient that he has normal vision and does not need spectacles.

b. You can tell the patient that his vision seems normal but he may need spectacles depending upon other factors.

c. You can tell the patient that he has normal vision, does not need spectacles, and does not have any eye disease requiring treatment.

8. ____________________________________ is a term which means poor night vision or night blindness.

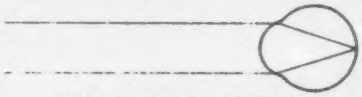
AMETROPIA

Ametropia is any refractive condition in which, when the eye is at rest, parallel rays of light do not focus on the retina. The ametropias (refractive errors) may be divided into hyperopia (farsightedness), myopia (nearsightedness), and astigmatism. A fourth condition, presbyopia, is a gradual loss of ability to focus clearly on near objects. (Presbyopia will be covered in a later section of this SW.) In a large population of people, depending on age group, there are from 10% to 25% who have no refractive error at all. This condition is called emmetropia. In emmetropia, when the eye is at rest, parallel rays of light do focus on the retina. (Figure 20)

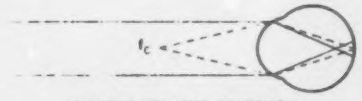
Hyperopia (Figure 20)

Hyperopia is a condition in which the light from a distant source would focus behind the retina when the eye is at rest. A hyperopic person with a sufficient accommodative reserve (ability to focus) can see clearly at both the farpoint and the nearpoint. Therefore, many hyperopes will have 20/20 vision without their spectacles. The optical system of a hyperopic eye is too weak for the length of the eye, i.e., the eye is too short for the optics. Hyperopia may be corrected by a plus (+) lens.

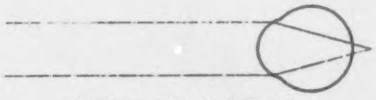
The term "farsightedness" is frequently used by the layman to indicate hyperopia. Farsightedness as a term is probably derived from the fact that hyperopes are more efficient visually at far than they are at near. A hyperope may be visually inefficient at both far and near, but he will always do better at far. Hence, the term farsightedness. However, it is not a good term.



NORMAL VISION (EMMETROPIA)



NEARSIGHTEDNESS (MYOPIA)



FARSIGHTEDNESS (HYPEROPIA)

Figure 20 Schematic Showing Relation of Image to Retina of Eye at Rest for Normal Vision and Two Types of Refractive Errors

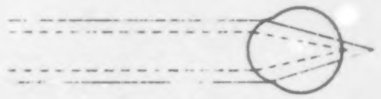
Myopia (Figure 20)

Myopia is the condition in which the light from a distance source focuses before it reaches the retina. Most myopes have reduced visual acuity at a farpoint but their near vision is frequently relatively good. In the myopic eye, the optical system is too strong for the length of the eye, i.e., the eye is too long for the optical system. Myopia is corrected by a minus (-) lens.

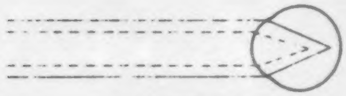
The term "nearsightedness" is the lay term which describes better vision at near than at far.

Astigmatism (Figure 21)

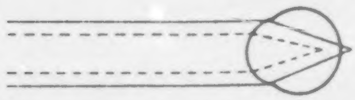
Astigmatism is a condition in which different meridians of the eye have different refractive powers. Most astigmatism is due to the shape of the cornea--one principal meridian of the cornea has a greater radius of curvature than the other. Some astigmatism may occur due to curvatures on other structures within the eye, the crystalline lens for example.



COMPOUND HYPEROPIC



COMPOUND MYOPIC



MIXED

Figure 21 Three Types of Astigmatism

The astigmatic eye may be subdivided into various types. Simple astigmia is a condition in which one of the line foci of the Conoid of Sturm falls on the retina and the other focus does not. Simple astigmia may be myopic or hyperopic.

Astigmatism may also be mixed. This means that one focus is on one side of the retina and the other focus is on the opposite side (one meridian is hyperopic while the other meridian is myopic).

Compound astigmatism also exists. In this case, both foci fall in front of (compound myopic astigmatism) or behind (compound hyperopic astigmatism) the retina.

Simple astigmatism is corrected with simple cylinders (planocylinders). Other types of astigmatism are corrected by spherocylinders. Review your Block I notes on cylinders and spherocylinders at this time.

Other Related Terminology

ANISOMETROPIA. This is the condition where one eye has a refractive error different from the other eye.

ANTIMETROPIA. This is a condition where one eye is myopic and the other eye is hyperopic.

ANISEIKONIA. This is also a defect of binocular vision in which the two retinal images of the same object differ in size. There may or may not be differences in refractive errors of the two eyes.

EXERCISE 17

Answer the following questions in the spaces provided.

1. The condition in which parallel rays of light focus on the retina when the eye is at rest is called ______________________________.

2. A patient has 20/20 VA at distance. He complains of blurred vision at near; his near VA measures 20/60. He probably has ____________________ or

____________________.

3. Hyperopia is corrected by ____________________ lenses. Myopia is corrected by ____________________ lenses. Astigmatism is corrected by ____________________ lenses.

4. Another term for refractive error is ____________________.

5. A hyperope can maintain clear vision if he has sufficient ____________

____________________.

6. Draw diagrams of the following refractive errors:

   a. Simple hyperopic astigmatism

   b. Simple myopic astigmatism

   c. Mixed astigmatism

   d. Simple hyperopia

   e. Simple myopia

MEASURING AND RECORDING VISUAL ACUITY

The visual acuity test is a portion of the subjective examination of the eyes, i.e., a portion in which the patient must respond in some manner to a stimulus presented by the examiner. In the performance of the various tests and the recording of the results, a set procedure should be established and followed. The eyes should always be tested and the results recorded in the same order so that there will be less likelihood of an error in the entry of the findings on the records. Procedures may vary slightly from clinic to clinic, but the following procedure is commonly used in testing the visual acuity of the eyes.

1. The test is made for each eye separately, the eye not being tested is covered during the test.

2. The right eye is usually tested first, and the result recorded immediately after completion of the test. The abbreviations "R" for right eye, or "O.D." for the Latin oculus dexter, may be used in recording results of the test.

3. The left eye is usually tested second, and the results recorded immediately after the test is completed. The abbreviations "L" for left eye or "O.S." for the Latin oculus sinister, may be used.

4. If both eyes are tested together after testing the eyes individually, the abbreviation "O.U." for oculus uterque, may be used.

5. If the patient wears glasses, tests of his visual acuity are normally given first without his glasses and then with his glasses. Screening or survey tests may be given with the "habitual Rx", meaning the patient takes the test with glasses (if any) if worn.

Two types of examinations are normally given in the eye clinic, a "manifest" or "dry" examination or a "cycloplegic" or "wet" examination. Visual acuities are recorded when the patient is "dry" for most procedures.

Farpoint Tests

ILLITERATE TESTS. If the patient is illiterate, or a child who cannot read letters, the tumbling E chart or Landolt C chart is used. The patient is asked to identify which direction the arms of the E or the break in the C point. Children may be asked to point their fingers in the same way the "fingers" of the picture point. Test procedure is the same as stated above.

SNELLEN TEST. If the patient is literate, the Snellen test card or Snellen (or Sloan) projectochart letters may be used. The Snellen test charts for distant vision contain square-shaped letters which diminish in size from the top line downward. The largest letter, which is on the top line, can be read by a person with normal vision at a distance of 200 feet (some charts have a 400 foot letter). The next lines can be read at 100, 70, 50, 40, 30, 20, 15 and 10 feet respectively. These distances are noted on the chart opposite each line of letters which can be read at that number of feet by a person with normal vision.

Score Recording

When completing a SF 88, vision will be recorded in the form of a fraction, and in round numbers, that is 20/20, 20/40 not 20/20 +2 or 20/40 -3. When completing a form used by the optometrist in his examinations, the use of a (+) or (-) symbol and the number of any additional letters read or missed is acceptable; therefore, if a patient correctly read the 20/30 line and three letters on the 20/25 line, his acuity would be recorded as 20/30 +3 for that eye. If the patient read the 20/40 line and all but two letters on the 20/30 line, his acuity would be recorded as 20/30 -2 for that eye. When completing a SF 88, correct reading of 75% of a line qualifies the examinee for successfully reading that line.

Nearpoint Tests

Near visual acuity is determined for each eye separately. For flying Class I and IA examinations, glasses will not be worn. For all other examinations, near vision will be recorded both with and without corrective lenses if glasses are worn or required. Individuals over 40 years of age may wear presbyopic corrections up to +2.50 D sphere when being tested for entries on a SF 88, and may wear any habitual Rx when being tested for a routine eye exam. Correction worn will be noted on the report of examination.

Near vision testing will be done using Chart Set, Vision Acuity Testing, Near Vision, FSN 6515-598-8077, at a distance of approximately 14". The examinee will be instructed to read the smallest print possible.

Near visual acuity will be recorded with the numeral 20 as the numerator when completing a SF 88, but when completing a clinical form, use of the numerator 14 is acceptable. See Table 3-4 AFM 160-17 insert for conversion information for nearpoint cards.

Night Vision

See Paragraph 3-9 of the AFM 160-17 insert to learn how to administer the night vision test.

The Projectochart

One of the most commonly used instruments in the clinic is the American Optical Projectochart (or the Bausch & Lomb equivalent), FSN 6515 388 3600, Projector, Ophthalmic Acuity Test. This instrument is essentially a slide projector with special ophthalmic slides. Screens are supplied with the instrument. Lens tubes may be specially designed for either a 15 to 20 foot room or a 10 to 14 foot room. Replacement bulbs (B&L #1217L) may be ordered through medical supply.

In order to accurately project a letter of the proper size and dimensions, the projectochart must be positioned with respect to the screen and patient. Elevation of the screen is accomplished by unlocking the set screws in the base of the stand and adjusting the supporting column. The projector tube should be on the same horizontal plane as the reflective screen. The proper size of the projected letters is assured by calibrating in the following manner.

1. Measure distance from screen to patient's eyes. Adjust chair, if possible, so that this distance is an even number of feet.

2. Place Projectochart 3 or 4 feet in front of patient and a little to one side. Plug instrument into a convenient 115 VAC outlet. Insert slide in top of instrument, then turn on instrument.

3. By loosening the knurled ring near the base of the tube, the objective lens will be allowed to slide in its mount. Adjust the objective lens so that the image of the letters is clear and sharp. Now place the test distance template supplied with the projector against the reflective screen. Adjust the screen-projector distance until the vertical dimensions of the 20/200 E coincide exactly with the vertical scale for the test distance which you are using. If your test template is missing, the following heights will be sufficiently accurate:

Chair-screen distance	20/200 E height
20'	89 mm
15'	66 mm
10'	44 mm

Intermediate heights may be interpolated.

4. Readjust the focusing tube and the screen-projector distance so that the proper size image is clear and sharp.

5. Mark the floor near the base of the stand to facilitate repositioning of the projector after moving it for cleaning or repairs.

The horizontal selector slide is used to provide either a full square image or a vertical line image. The red-green filters are provided to be used in the Duochrome test. Due to the chromatic aberration of the eye, a hyperope will see letters in the green clearer than letters in the red. The opposite is true for a myope. The vertical slide control knob is provided to change projected areas of the slide. The small lever horizontal line selector provides a horizontal line of letters, or in conjunction with the vertical line on the selector slide, will provide viewing of single letters.

Maintenance of the Projectochart is relatively easy. Clean the glass slides and lenses in the focusing tube by wiping them with a soft, dry clean cloth. Never attempt to remove the lenses from the focusing tube. Lamp replacement is accomplished in the following manner: Press lamphouse release button near top of lamphouse, allow lamphouse section to swing back on its hinges, remove inner lamphouse by pulling top back toward you until spring clips have disengaged, then lift out; the lamp has a bayonet socket and may be removed by pressing down, twisting counterclockwise, then lifting out. Do not attempt any further disassemblage! CAUTION: If the lamp was on prior to removing the bulb, the housing may be extremely hot. Before inserting new lamp, insure that all fingerprints have been wiped from it, otherwise the bulb may crack when hot.

The VTA-ND and the Keystone Unit

Refer back to the inserts near the end of this study guide to learn how to perform visual acuity tests using either the VTA-ND or the Keystone Unit.

EXERCISE 18

Answer the following questions in the spaces provided.

1. In measuring visual acuity which do you test first: right eye, left eye, or both eyes together? ______________________________

2. If a patient is in the clinic to receive a cycloplegic refraction, is the visual acuity test administered before or after the administration of the drops?

____

3. O.D. means ______________ ______________.

O.S. means ______________ ______________.

O.U. means ______________ ______________.

4. List the test sequence for the VTA-ND.

Slide 1: ______________________________

Slide 2: ______________________________

Slide 3: ______________________________

Slide 4: ______________________________

Slide 5: ______________________________

Slide 6: ______________________________

Slide 7: ______________________________

Slide 8: ______________________________

5. An exam room is 20 feet long. The distance between the patient's eyes and the reflective screen of a projectochart is 18 feet. When the projector is at the proper distance, what will be the correct height of a 20/200 letter E?

____

SCREENING FOR AMBLYOPIA OR AMETROPIA

Sometimes a patient is found who has healthy eyes, but he cannot see well with one eye. If the patient's vision cannot be improved by sighting through a pinhole, or by lenses, he is said to be amblyopic. Clinical ambylopia is about 20/30 or worse, uncorrectable, in either eye.

Usually ambylopia is associated with strabismus (heterotropia), and may begin with suppression of vision in one eye. Suppression is a "turning off" or ignoring of the vision of one eye while both eyes are open. Suppression is the visual system's way of canceling double vision (diplopia) caused by strabismus. Sometimes suppression develops as a result of blurred vision in one eye caused by anisometropia. Suppression can only be found when the patient has both eyes open; if the non-suppressing eye is covered, the suppressing eye "comes back on" and usually can see pretty well if any refractive error is corrected. On the other hand, if the patient has amblyopia, when the non-ambylopic eye is covered, the ambylopic eye still cannot see well.

The pinhole test is often used to screen for ambylopia or to estimate the patient's BVA (best visual acuity). If a patient shows poor VA on the standard visual acuity test, give him the pinhole disc from the trial lens case and instruct him to hold the disc in front of his poor eye while occluding the other eye. If the diminished acuity is due to a refractive error, the patient's acuity will improve with use of the pinhole; if the eye is amblyopic, no improvement in VA will occur. Sometimes an eye is both ambylopic and ametropic; in such a case the pinhole would improve the VA to whatever extent permitted by the amblyopia. For example, if an astigmatic eye shows 20/100 unaided and 20/50 with best correction (by a lens), a pinhole would also be expected to bring the eye close to 20/50. In other words, the 20/100 could be thought of as being due to the combination of refractive error and amblyopia, while the 20/50 could be thought of as the patient's VA (BVA) when the refractive error is eliminated. Thus, the patient is ambylopic to the extent of 20/50.

When you perform a pinhole disc test, the score should be recorded as 20/X P.H. If a patient reads 20/30 through the pinhole, then record 20/30 P.H., etc.

The plus lens test may be administered in conjunction with any standard farpoint VA test. This procedure is designed to detect moderate to severe hyperopia in patients who otherwise pass a screening test. The procedure is the same as the basic farpoint visual acuity screening test except that a +1.25 D sphere is held before the eye being tested. If the patient can still read the 20/20 line through the plus lens, he is evidently hyperopic to an extent equal to or greater than +1.25 D, and fails the test. He liked the plus, so he probably needs the plus and should be referred to the optometrist for evaluation.

If the plus lens test is used in your clinic, it should be recorded as "Plus lens test, fails" or "Plus lens test, passes", on your local form.

EXERCISE 19

Answer the following questions in the spaces provided.

1. If a patient's eye is healthy but has a visual acuity worse than 20/30 which cannot be corrected by lenses or by sighting through a pinhole disc, he probably has ______________________________.

2. Which eye would you expect to be amblyopic if the cover test shows a left hyper-exotropia? ____________________

3. The pinhole disc test could be used to differentiate between ______________ and ______________. The plus lens test is used to detect ______________ in patients who have a habitual VA of ______________.

4. A patient has O.D. 20/200 and O.S. 20/50. He has no spectacles. Through the pinhole disc he has O.D. 20/30 and O.S. 20/20. Make proper entries of these findings below.

5. A patient has 20/20 with either eye. He has no spectacles. His VA through a +125 D sphere is 20/50 with either eye. Make proper entries of these findings below.

6B-16-544

6. A patient has O.D. 20/60 and O.S. 20/60. A pinhole test corrects each eye to 20/25. What do you think is causing the 20/60? ____________________

____

____

7. A patient has O.D. 20/20 and O.S. 20/30. A pinhole test gives O.D. 20/20 and O.S. 20/20. A plus lens test gives O.D. 20/60 and O.S. 20/80. What do you think the patient may need? ______________________________

____

____

8. A patient has O.D. 20/200 and O.S. 20/400. A pinhole disc test on the O.D. gives 20/25 and on the O.S. gives only 20/200. What is probably wrong with the O.D.? ____________________

What is probably wrong with the O.S.? ____________________

9. A hyperope enters the eye clinic wearing O.U. +5.00 D spheres. His VA through his old spectacles (O.U. +5.00 D sphere) is O.D. 20/20 and O.S. 20/20. You administer a plus lens test (+1.25 D sphere) with the old Rx still on the patient and you record "Plus lens, fails". Would you refer the patient to the optometrist? If so, why? If not, why not? ____________________

10. If a patient gets improvement in VA no matter whether you use a pinhole disc or a plus lens, he probably has ____________________.

11. A patient enters the office wearing the following Rx:

O.D. -1.00 D sphere
O.S. -1.75 D sphere

These lenses correct his vision to:

O.D. 20/40
O.S. 20/40

You administer a plus lens test over his spectacles and his vision worsens. Then you administer a pinhole test and his vision improves. Why? ____________________

12. Differentiate between suppression and amblyopia.

AMPLITUDE OF ACCOMMODATION AND PRESBYOPIA

Accommodation can be described as a focus adjustment which the eye must make in order to see clearly at different distances. Although many theories have been advanced as to how the eye accomplishes the act of accommodation, they all agree that the adjustment of focus is affected by changes in the convexity of the crystalline lens.

In the case of an emmetropic eye (i.e., an eye with no refractive error), no accommodation is required to view clearly an object located at distance. (Note: The term "distance" refers to clinical infinity. Clinical infinity is a distance of 20 feet or greater.) As an object is brought closer and closer to an eye, the eye is required to add more and more plus (+) power into its optical system in order to continue to see details of the object clearly. This is because light coming to the eye from points closer than infinity has a (-) or diverging wave front. To overcome this, the crystalline lens in accommodation increases in convexity (plus power). Although there are evidently other stimuli to accommodation, a blurred image on the retina seems to be one of the most important reasons an eye is stimulated to accommodate.

When accommodation is relaxed, the point in physical space which is in focus on the retina is called the Punctum Remotum (P.R.) or far point of that eye. For an emmetrope, the P.R. would be located at infinity. A myope's P.R. would be nearer than infinity, at a distance corresponding to the refractive error of the eye. A hyperope has a P.R. at "negative infinity", i.e., behind the eye at a distance corresponding to its refractive error.

When an eye is accommodated to its maximum, the physical point which is conjugate (in focus) to the retina is called the Punctum Proximum (P.P.) of that eye. The range of accommodation is the linear distance between the P.R. and the P.P.

The maximum amount of accommodation which an eye can produce is called the amplitude of accommodation. This is measured by determining the nearest distance, converted to diopters, at which a test object can still be recognized.

The amplitude of accommodation may be influenced by many things, but the largest factor is age. Accurate measurements have shown that the average amplitude of accommodation of 10 year olds is about 14.00 D. By the age of 70, the amplitude has dropped to 0.25 D.

When an individual reaches an age where he can no longer accommodate for his normal reading distance, for a while he may be able to "gain" a little bit by holding his reading material out at arm's length. You will frequently see patients who will express their chief complaint as "my arms are getting too short". A patient with this chief complaint is really telling you that his punctum proximum is receding because of his decreasing amplitude of accommodation. In most cases this symptom is a result of a normal aging process, and it will tend to worsen noticeably for several years after its onset. The condition is called presbyopia.

Presbyopia usually has its onset about the age of 40, although, as we stated before, amplitude of accommodation actually begins to decrease at a much earlier age. The correction for presbyopia involves replacing the "lost" plus (+) power of the eye by spectacles or so-called "reading glasses". If the patient is already wearing an Rx for distance vision (or is in need of one), it is necessary to provide the extra plus (+) power needed at near in the form of bifocal lenses.

Figure 22 shows the decline in amplitude of accommodation that occurs with age. As you can see, presbyopia will advance with age whether or not the patient wears glasses. Therefore, some patients' statements regarding the theory that their glasses made their eyes worse are in error.

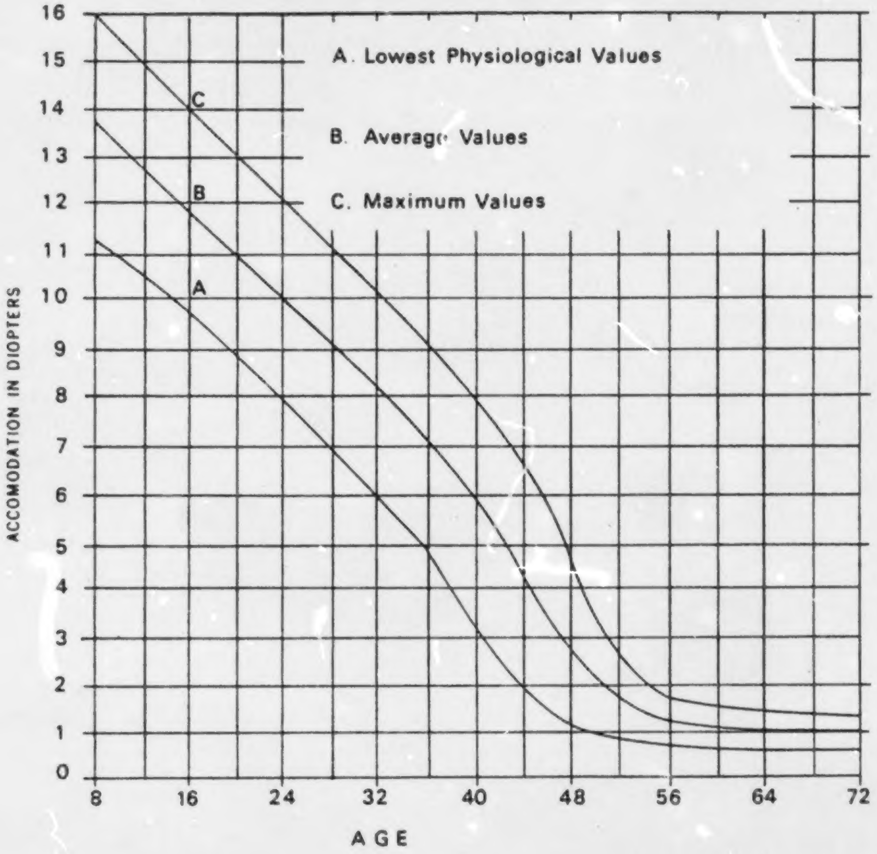


Figure 22

MEASURING AMPLITUDE OF ACCOMMODATION

There are several ways of measuring a patient's amplitude of accommodation. As an optometry technician you may be required to conduct a test called "Nearpoint of Accommodation". This test is conducted during specific types of flying physical examinations. The results of the test are recorded in the appropriate order under Item 63 of SF 88. The test is administered with the aid of a Prince Rule and an accommodation card. The zero point on the rule should be placed 15 mm from the cornea. The accommodation card should be placed so near to the eye that the examinee cannot read it. Then slowly move the card away from the patient's eye until the point is reached where he can correctly read print having a vertical height of 1 mm (.62 M or J 2). The distance from the eye can be read from the Prince Rule in diopters of accommodation and recorded. The test should then be repeated for the other eye. If a Prince Rule is not available, dioptric values can be computed by dividing the nearpoint in inches by 40 or in centimeters by 100. If the examinee has correcting spectacles, these will be worn while nearpoint of accommodation is being determined.

AFM 160-1 has a table of accommodative powers which are expected as minimum values for given ages. Examinees required to take the nearpoint of accommodation test as part of their physical examination will be qualified or not qualified on the basis of this table of minimum values. The following values are extracted from AFM 160-1.

AGE	DIOPTERS	AGE	DIOPTERS
17	8.8	32	5.1
18	8.6	33	4.9
19	8.4	34	4.6
20	8.1	35	4.3
21	7.9	36	4.0
22	7.7	37	3.7
23	7.5	38	3.4
24	7.2	39	3.1
25	6.9	40	2.8
26	6.7	41	2.4
27	6.5	42	2.0
28	6.2	43	1.5
29	6.0	44	1.0
30	5.7	45	0.6
31	5.4		

The student should note that the above values are not meant to correspond with those on the graph in Figure 21, although it is easy to see a similar relationship between the minimum values of accommodation the Air Force has established for examinees and their age.

By this time you are probably wondering what causes the decrease in accommodation values with age. It is generally agreed that the decline is due to a gradual loss of elasticity by the crystalline lens.

EXERCISE 20

Answer the following questions in the spaces provided.

1. A patient changes fixation from an object at a distance of 15 feet to another object at 10 feet. Would his eye require more or less plus (+) power with that change? ______________________________

2. An eye which cannot add plus power to its optical system has zero amplitude of ____________________________________.

3. ________________________________ has its onset about the age of 40.

4. A ruler marked only in centimeters and millimeters is used to measure a patient's nearpoint of accommodation. The test card has print 1 mm high and the patient read it correctly first at 100 mm with the O.D. and at 120 mm with the O.S. What is his nearpoint of accommodation expressed in diopters?

O.D. __________________

O.S. __________________

5. A 21 year old examinee is taking a flying physical requiring a test of his accommodation. According to the table of minimum values, is he qualified if his nearpoint of accommodation is O.D. 7.5 D and O.S. 7.7 D? _______________

6. How much accommodation is required for an emmetropic eye to see clearly at a distance of 16 inches? ______________________________ How much accommodation is required by a 1.00 diopter hyperope to see clearly at 16 inches? ____________ How much accommodation is required by a 1.00 diopter myope to see clearly at 16 inches? _______________

7. One presbyope is found to have small pupils (2 mm in diameter). Another presbyope has rather large pupils (5 mm in diameter). Which presbyope would you expect to have the most difficulty with reading? ____________________

____

8. What is the difference between measuring the patient's near visual acuity and measuring his nearpoint of accommodation? ____________________

____

9. A 3.00 D myope is reading a book at 13 inches. How much accommodation does he need to see the print clearly? ____________________ Where is the punctum remotum (P.R.) of a 3.00 D myope? ____________________ (Assume that he has no spectacles.)

10. In question 9 above, if the 3.00 D myope has a nearpoint of accommodation without spectacles of 10.0 D, what do you expect his nearpoint of accommodation would be if he then took the test when wearing his spectacles? ____________

CUES OF DEPTH PERCEPTION

In flying, driving, and many other performance functions which rely on visual cues, the ability to perceive depth is of great importance. An individual can determine the relative distance of objects by using at least eight cues directly related to vision. The first of these cues is OVERLAY; if an object overlaps another object, the overlapping object is closer. Another cue is RELATIVE SIZE; objects seen as larger are usually closer. PERSPECTIVE is also an important cue; two-dimensional drawings and photographs give the illusion of depth by proper use of perspective. An object located in the far distance is partially obscured by DISTANCE HAZE, and this may be used as a cue to its relative distance. PARALLAX, the relative change in position of an object with movement of the observer is an important cue. Near objects may be judged as to relative depth by the brain measuring the amount of CONVERGENCE of the eyes needed to maintain single binocular vision when looking at each object. The amount of ACCOMMODATION needed to keep each object clear may also be a cue. The last, and perhaps the most important cue to fine depth discrimination at medium to near distances, is STEREOPSIS. Since the eyes are located a little ways apart, an object will have an image on a slightly different place on each retina in relation to other objects in the visual field. This retinal displacement is interpreted by the brain as a difference in depth. All clinical depth perception tests measure stereopsis, and attempt to eliminate the presence of other cues. The Verhoeff Stereoptor uses an actual difference in depth of test rods to achieve this, while the VTA-ND and Keystone instruments use special photographs with one portion of the target line displaced laterally to simulate depth. Stereopsis is called a primary cue to depth perception, while the other cues are secondary.

EXERCISE 21

Answer the following questions in the spaces provided.

1. List eight cues to depth perception.

2. List two binocular cues to depth perception.

3. Can a person with heterotropia have depth perception? Explain.

4. Can a person with heterotropia have stereopsis? Explain.

5. Which cue to depth perception is the primary cue?

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DETERMINING CLINICAL DEPTH PERCEPTION (STEREOPSIS)

There are several types of "depth perception" apparatuses in use in the Air Force. Depth perception testing is required on examination for flying, and now some states require depth perception testing for drivers' license applications or renewals. Depth perception testing is also frequently a part of normal visual screening programs and occupational vision surveys.

For flying examinations, the VTA-ND is the standard screening test for depth perception, but is the most difficult for some examinees to pass even though their fusion and depth perception are normal. Visual acuity less than 20/20 in either eye also makes the test very difficult or impossible to pass. If the VTA-ND is not available, or if the examinee fails the standard test, the Verhoeff depth perception apparatus (DPA-V), or the Howard Dolman apparatus (H-D) is acceptable. Record the name of the test used in item 65 of SF 88 and the test results, corrected or uncorrected, in the spaces provided. On the VTA-ND, results should be recorded as passes through D, E, or F. The results on the DPA-V will be recorded simply as passes or fails, and the results on the H-D will be recorded as the average error in millimeters on not less than five trials.

Driver testing and other visual screening projects involving depth perception testing can also be accomplished with the VTA-ND, DPA-V, or H-D. However, the Keystone Telebinocular is also a very useful instrument. You should study the AFM 160-17 insert and the Keystone insert to learn the correct procedures for administering the depth perception tests available on these instruments. Do this before answering the questions in Exercise 22.

An excellent apparatus for testing the existence of stereopsis with small children is the Stereo-Fly Test. You will receive verbal instructions from your instructor in the administration of this simple test.

EXERCISE 22

Answer the following questions in the spaces provided.

1. List five apparatuses which can be used to determine depth perception (stereopsis).

2. What is the correct test distance in conducting the Verhoeff test?

3. What is the correct test distance in conducting the Howard-Dolman test?

4. If an examinee makes one error in eight Verhoeff presentations, what do you do next?

5. AFM 160-1 states that an examinee with an average error of greater than 30 mm on the Howard-Dolman depth perception test fails Class I, Class IA, and Class II physicals. If an examinee has consecutive readings of 20 mm, 35 mm, 35 mm, 30 mm, and 25 mm, does he have a passing score? __________ What is his average score?

6. If an examinee gets eight out of eight correct on the Verhoeff test, how is the score reported, i.e., recorded on SF 88?

7. AFM 160-1 states that an examinee must give correct answers through Group D of the VTA-ND depth perception test in order to qualify on Class I, Class IA, and Class II physicals. If an examinee gets all answers correct through Group D, what should you record on the SF 88?

8. On the VTA-ND test for depth perception, what is the purpose of the arrow?

CHARACTERISTICS AND ANOMALIES OF COLOR VISION

Characteristics of Color

The sensation of color consists of at least three components completely related to physical characteristics of the stimulus and to the illuminant under which the stimulus is viewed. These components are hue, saturation and brightness. The hue of an object--whether it is red, green, violet, etc.,--is most closely related to the dominant wavelength of the light it emits or reflects; this relationship can be seen when sunlight is split into components of different wavelengths by passing it through a slit and prism. Saturation, the purity of a color, is related to the amount of white light mixed in with the color; it often depends in large part on the type and amount of the illuminant. Chromaticity is a word describing the linkage of hue and saturation which combine to produce what we see and describe as a color. Brightness is related to the rate of transfer of luminous energy-the amplitude or amount of energy reaching our eye. Color is usually specified in terms of all three components, the most common systems being a tristimulus system such as the ICI or a color solid such as the Munsell Solid. In these systems, wavelength, purity and amplitude are plotted on special graphs (See Figures 23 and 24), and the locus of the points yields the "color" of the object. However, all of these components interract to some extent--for example, a bright red will appear to be of a different hue than a dull red of the same wavelength.

A spectrograph is an instrument which uses prisms or gratings to produce monochromatic light, and a split-field anomaloscope is an instrument used for comparing two colors. Each side of the split field has a light source which produces known amounts of red, blue and yellow light (or any three primaries), and each of these primary colors is independently adjustable. First use of these types of instruments was probably to determine the number of hues that an individual can see, and it was found that most people can differentiate 128 separate hues or tints. At the blue-green and yellow portions of the spectrum, the eye can detect a change of as little as a millimicron, while at the red end, 20 mu may be needed to discriminate hue. If saturation as well as hue are varied, the eye may be able to differentiate as many as 500,000 color sensations. Somebody got the bright idea to attempt to match a monochromatic light in one half of the anomaloscope with a mixture of three primaries, and for most people got fairly consistent results; that is, a mixture of three wavelengths on one side appeared to be the same color as a single wavelength on the other side, and most people thought that both sides were the same color. However, a very small percentage of subjects made "matches" which made no sense to other subjects, one side might appear dark blue and the other side might appear dark red!

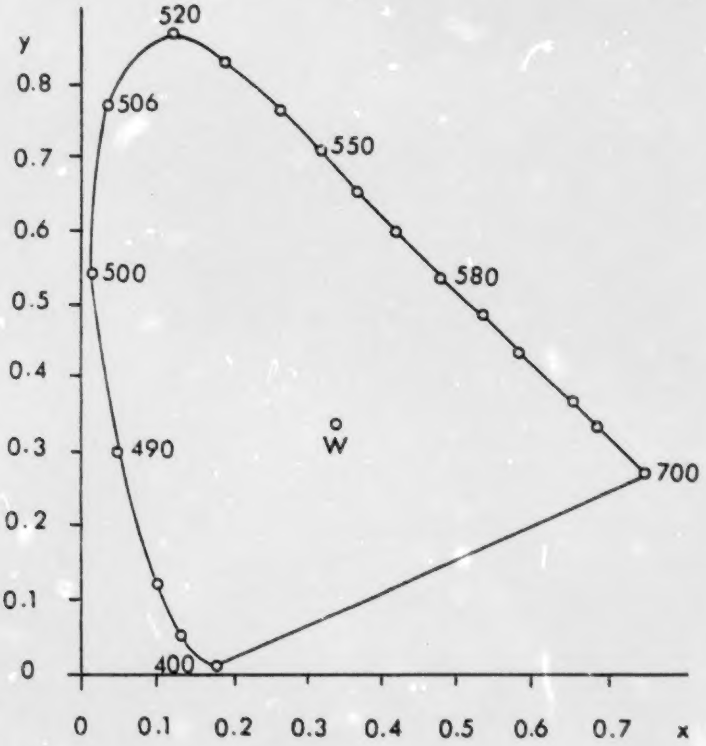

Figure 23

Color Vision Theories

Thomas Young (1773-1829) was among the first to study color vision scientifically. He realized that the eye saw many thousands of different colors, and that it would be impossible for each color to have a corresponding receptor if visual acuity were to remain at any acceptable level under colored light. Young knew that there were three primary colors, and decided that this was a physiological attribute of man rather than a physical attribute of light. Young described a theory of color vision based on these premises, but it was not promulgated until several years later when Helmholtz modified and published a slightly different version called the "Young-Helmholtz trichromatic theory". This theory is based on a triangle with the three primary colors (either red, yellow and blue or red, green and violet) at each apex. If mixed in the proper proportions, either of these two sets of primaries will yield any other spectral color or white. The theory further states that there is a substance contained within each cone that is sensitive to one of the primary colors; if all the substances are stimulated equally, we see white, if none of the substances are stimulated, we see black. If the substances are stimulated unequally, we see the color corresponding to the amount of each substance stimulated. A great controversy arose over the question of whether yellow was a primary or the result of a red-green mixture.

At about the same time that Helmholtz was expounding his theory of color vision, a Dr. Hering formulated his "theory of opposing colors". Hering stated that there are four basic colors in the spectrum--red, yellow, green and blue--and that two pairs always oppose each other. Red and green opposed each other, and yellow and blue opposed each other. The catabolism (breakdown) of a substance contained in a cone was supposed to produce a "warm" color (red, yellow or white), while the anabolism (buildup) of this substance produced the "cool" colors (green, blue or black). Hering agreed that there were either three different substances or three different types of cones contained in each retina to produce these effects. Hering's theory does not explain certain types of color blindness.

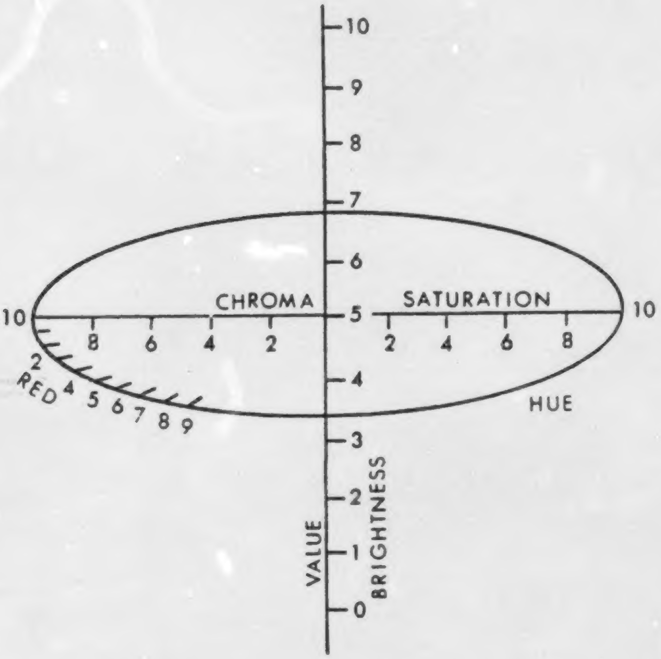

Figure 24

Abnormal Color Vision

The person with "normal" color vision is said to be TRICHROMATIC--that is, he needs a mixture of three primaries to match any other color. Some people (2.6%) need only two colors to match any other color, and the mixtures they make with their two colors are pretty strange to the trichromat. The people who need only two colors are called DICHROMATS, and are subdivided into two types - PROTANOPES, people who could not see red, and DEUTERANOPES, people who could not see green. Actually, protanopes have extreme difficulty in discriminating the longer wavelengths of the visible spectrum--red, orange, yellow and green appear to have the same hue! Deuteranopes, on the other hand, can see "green" (although they don't see it as trichromats see it), but confuse "green" with red, orange and yellow.

Further investigation found a group of trichromats who used three primaries to make a match, but used the wrong amounts--mixing a bright red to match a pink for instance. These people are called PROTANOMALOUS TRICHROMATS (red-weak), while the people who are green-weak (use too much green to make a match) are called DEUTERANOMALOUS TRICHROMATS. About 5.4% of the population seems to have this problem.

A third group was readily evident, about 0.00001% of the population would match one half of the anomaloscope by using only one color! These people are called MONOCHROMATS. A long series of studies found that 99.5% of women have normal color vision, but only about 92% of men have normal color vision.

EXERCISE 23

Answer the following questions in the spaces provided.

1. When we speak of color or hue of an object, we are also referring to the dominant ______________________________ of light the object is emitting or reflecting.

2. A person with normal color vision is said to be ______________________.

3. An automobile is painted red. What color(s) does the paint reflect?

______________________________ What color(s) does the paint absorb?

____

4. If you were conducting color vision tests on a group of school children, would you expect color vision deficiencies to be more common among the girls or among the boys? ____

5. Is the human eye more sensitive to wavelength changes in light of color blue or of color red?

6. What color gives a protanope the most trouble?

COLOR VISION TESTING

Several screening tests have been devised to determine who is "color blind" among the population. In the Air Force the standard screening test for color vision is the Vision Test Set, Color Vision (VTS-CV), also called Plate Set, Pseudoisochromatic, 15 plates, FSN 6515-299-8186. This set consists of one demonstration plate and 14 test plates in a ring binder. This test must be administered under the easel lamp listed as Light, Color Perception Testing, FSN 6515-345-6625. Any other light source alters the colors perceived by the examinee and renders the test results invalid. If the examinee cannot pass the screening test, he will be tested with the Vision Test Apparatus, Color Threshold Tester (VTA-CTT), FSN 6515-388-3700. The purpose of the VTA-CTT is to quantitate the degree of color vision deficiency. A score of 50 or better on the VTA-CTT indicates a mild or Grade 1 deficiency, considered safe for aviation. A score from 35 to 49 indicates a moderate or Grade 2 deficiency, and a score of 34 or less indicates a severe or Grade 3 deficiency. If the examinee passes the screening test, the proper entry for item 64, SF 88, is "VTS-CV Passes". If the examinee does not pass the screening test, enter "VTS-CV Fails" and the number of plates missed, and then record the score of the VTA-CTT in item 73 of SF 88. Congenital color vision deficiency does not change throughout life. Once the degree of color vision deficiency has been established by careful testing, repetition of the testing is unnecessary. The entry "On Record" and the results of previous testing is sufficient, but caution is urged so that invalid test results are not perpetuated.

Air Force regulations have recently allowed the use of a second quantitative test if the VTA-CTT is unavailable. This test is the Farnsworth Lantern (FALANT). Instructions for administering the test are printed on the instrument case. If the examinee passes the test, the proper entry for item 64, SF 88, is "FALANT PASSES". If the examinee fails the test then "FALANT FAILS" should be entered.

You should now refer to your AFM 160-17 insert to learn how to administer the VTS-CV and the VTA-CTT. There is also a color test in the Keystone system, so read that section too. Note that the Keystone color test is not for use for physical examinations, but it is a useful adjunct to the normal clinic screening.

EXERCISE 24

Answer the following questions in the spaces provided.

1. If an examinee fails the VTS-CV, it is possible to quantitate his color vision deficiency by using the ______________________________.

2. In order to pass the color threshold test a score of ______________ or better is necessary.

3. How many incorrect responses are permitted to pass the VTS-CV? ____________ How many incorrect responses then must the examinee give you to fail the test?

____

4. An examinee misses 8 of 15 plates on the VTS-CV. Make the appropriate entry which should be made on Item 64, SF 88. ________________________

____

5. In question 4, if you then conducted a color threshold test on the examinee and he scored 48, make the appropriate entry for this test and the result.

____

Under what item or paragraph of SF 88 would this entry be made? ___________

____

6. Can the color plate test be administered with only normal room lights on?

________ Explain.

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OCULAR EMERGENCIES AND FIRST AID

OBJECTIVES

The purpose of this Study Guide and Workbook is to give you basic knowledge in the following areas:

1. Emergency/first aid treatment in ocular trauma
2. Other ocular emergencies
3. Medical records in an ocular emergency

INFORMATION

EMERGENCY/FIRST AID TREATMENT IN OCULAR TRAUMA

Although the primary mission of the optometry clinic involves problems related to the "healthy" eye, in the absence of an ophthalmology clinic, the optometry clinic frequently becomes the referral point for ocular emergencies. It is important for the optometry technician to acquire a knowledge of proper first aid procedures. Often prompt application of first aid treatment in an ocular emergency may be the means of saving an eye or preserving the vision of the patient. The information provided below is designed to acquaint you with some of the more common ocular emergencies and their proper initial treatment.

Chemical Trauma

There are many duties in the Air Force which require individuals to work around chemicals which are potentially hazardous to the eye. Chemical burns are exceedingly common from battery acid, cleaning fluids, and lime.

In general, the immediate treatment for most chemical burns is prolonged irrigation with clean water or normal saline. We must stress the importance of the word "immediate" because it is not uncommon for a report to come to the optometry clinic by telephone that a chemical has been splashed into an eye. The optometry technician answering the call must be aware that treatment on the spot is absolutely necessary. The technician should instruct the patient to hold his eye open under a steady stream of water. Use any clean water available, i.e., the patient may have to hold his head under a faucet or even put his face into a bucket of water and blink his eyes rapidly. Sometimes the pain may produce blepharospasm making it very difficult for the patient to hold his eyelids open during the irrigation without finger assistance. In order for irrigation to be effective, the eyelids must be held open.

ACID BURNS. Acid burns have a better prognosis than many other types of chemical burns. Acid burns do not penetrate the eye as do burns from alkali. Acid burns cause almost instantaneous local tissue destruction at the point of contact and do not penetrate the underlying tissue as readily as alkalis.

Immediate treatment consists of immediate irrigation. The eyelids should be held open. If the patient is in extreme discomfort, a drop of proparacaine can be instilled. Continue irrigation for 20 to 30 minutes. If an attempt is to be made to try to neutralize the acid in the eyes, irrigation can be carried out using a 3% solution of sodium bicarbonate (do not try to hurry the process by using a stronger solution). A method to determine if the acid is neutralized is to use pH paper. Touch the end of the pH paper to the fluid in the conjunctival sac; if the paper turns pink, there is some acid remaining in the eye, and irrigation should be continued. If the patient is still showing discomfort, do not repeat the topical anesthetic without authorization since tissue regeneration is slowed by use of topical anesthetics.

After the irrigation has been initiated and the patient somewhat stabilized, the patient should be transported to an ophthalmologist as soon as possible. If eye irrigation can be performed in the ambulance, it will be possible to get the patient into the hands of an ophthalmologist that much sooner. Because of the danger of adhesions, it is usually better to delay applying a bandage, until the ophthalmological examination has been completed. At that time an ophthalmic ointment will probably be applied and other appropriate therapy instituted.

ALKALI BURNS. Unlike acid burns, strong alkalis have a tendency to produce a sustained reaction with the ocular tissues. Progressive damage to the eye will continue until the alkali is either removed by irrigation or neutralized.

Immediate treatment is copious irrigation of the eyes for at least 30 minutes. Use water or, if available, 1%-2% solution of acetic acid to neutralize the alkali. Once again pH paper can be used to determine the neutrality of the tears in the conjunctival sac. In burns caused by an alkali, the pH must remain normal for at least 7 minutes after irrigation is stopped. If not, irrigation must be resumed. It may be necessary to continue the irrigation for hours. The patient should be placed in the hands of an ophthalmologist as soon as practical, however, irrigation must not be interrupted until there is assurance that the alkali has been completely neutralized.

TF- 76-569

OTHER CHEMICAL BURNS. Lime burns are common among plasterers and other construction workers. Initial emergency treatment is copious irrigation with water. Any particles of calcium should be removed from the conjunctival sac if possible and refer the patient to an ophthalmologist for follow-up care.

Refrigerator gases are also caustic to ocular tissues. Sulfur dioxide is used in some cooling plants, or may be encountered as a pollutant from chemical or industrial processes. Sulfur dioxide burns should be treated the same as acid burns. Other refrigerator gases include F-12 and F-14. Note that F-12 and F-14 are insoluble in water, so water irrigation is useless. Instead, use olive oil as your irrigator.

Mustard gas could be encountered in a combat situation or in an industrial accident. Since this agent is activated by water, do not irrigate the eyes with water. Use a bland oil to wash the eye or other affected tissue.

Tear gas or mace is frequently used in riot control. The concentrations used in riot control produce irritation, lacrimation, and blepharospasm. Recovery usually occurs in a short span of time. However, if a tear gas explosion accidently occurs at short range, it is possible that the high velocity of the material at short range could cause the material to penetrate the eye with severe damage to lids and eyeball. Emergency treatment consists of irrigation. If available, irrigate with 0.4% sodium sulplute in glycerin or with glycerin alone.

Indelible pencil (analine pencil) injuries are extremely dangerous. Analine dye may cause blindness in a matter of days. Treatment consists of removing all particles of the pencil from the eye, then instilling a few drops of 2% sodium fluorescein solution every 5 to 10 minutes for at least 2 hours. The eye should be irrigated between applications of fluorescein.

Radiation Trauma

Ocular radiation injuries may be incurred from many sources: furnaces, X-ray equipment, welding equipment, radioactive materials, radar transmitters, and the sun.

ULTRAVIOLET RADIATION. UV radiation may be encountered from the sun or from sun lamps, mercury vapor lamps, electric welders or similar equipment. "Snow blindness" is a term used for ultraviolet radiation damage to the eyes caused by solar UV reflecting from large snow fields. Usually, UV damage has a latent period of several hours (just like a sunburn), and results in a keratoconjunctivitis (an inflammation of the cornea and conjunctiva). The threshold dose for UV injury to ocular tissues is about twice that of skin (sunburn). Immediate treatment is symptomatic, and usually consists of alleviating the pain with cold compresses. Certain drugs may be used to further alleviate pain and to prevent secondary complications. Most of the radiation burns seen as emergencies are due to ultraviolet.

INFRARED RADIATION. IR radiation may be encountered from furnaces, heat lamps, electric heating coils, etc. Damage to the eye is usually deeper than that seen with UV burns. Although not encountered as an ocular emergency, prolonged exposure to IR radiation may result in cataract. The so-called "glass-blower's cataract" is an occupational hazard of glass workers, for example, occurring several years after chronic exposure to IR radiation. Eclipse burns of the retina may be seen as an emergency caused by gazing at the sun or a solar eclipse. There is a sudden loss of central vision due to the concentration of infrared rays on the macular area of the retina. Permanent blindness of the affected retinal area may result. Prognosis and treatment depends on the extent and severity of the burn; it is usually palliative. The threshold dose for ocular damage due to IR is below that for skin tissue.

HEAT (FLAME) BURNS. If a person is burned about the face or eyelids from a fire, the eyelids usually close rapidly to protect the eyeballs. An actual burn of the ocular tissue should be treated in the same manner as an acid burn. The eyes may be covered with a sterile moist dressing before transporting the patient for specialized care.

VISIBLE LIGHT. Most authorities agree that visible light does not damage the eye. Some cases of retinal burns due to extremely high doses of visible light have been reported.

X-RAYS AND GAMMA RAYS. The type of lesion experienced depends on the voltage of the X-ray machine and the portion of the eye affected. Soft X-rays (8-25 KV) may cause keratoconjunctivitis. The threshold for soft X-rays is about 1000 r. Hard X-rays (100-1000 KV) will cause cataracts after a dose of about 500-800 r, and they will also cause keratitis after a latent period of several weeks. Radium (electron) burns may cause keratoconjunctivitis after a long latent period. The burns described in this paragraph are usually not in the province of first aid therapy.

ELECTRIC SHOCK. Although not seen as an ocular emergency, electric shocks may cause a cataract after a very long latent period.

Mechanical Trauma

Mechanical trauma of the eyeball is an all too common event. Snowballs, baseballs, handballs, hockey pucks, etc., are common causes of blunt ocular trauma. Small metallic or carbon particles and glass are common causes of foreign bodies in the eye. However, there is no end to the variations of mechanical trauma which one may encounter.

LACERATIONS AND CONTUSIONS. Lacerations of the eyelids may appear very serious, but if the eyeball is not involved, there will be no impairment of the patient's vision. However, lacerations of either the cornea or sclera may produce loss of sight.

When the eyelids are lacerated and the eyeball is not involved, bleeding may be controlled by application of a pressure dressing. However, if the eyeball itself is lacerated, pressure should not be applied to the eye because aqueous and/or vitreous would be displaced and irreparable damage done to the eye. The patient should be placed on his back immediately. Both eyes can be covered with a loose dressing to minimize movement of the injured eye. The patient should then be gently placed on a litter for transport to surgery.

A common form of corneal abrasion is caused by wearing contact lenses too long. If a patient has worn his contact lenses beyond the normal wearing time, shortly after removing his contact lenses, a severe pain will develop in one or both eyes. The typical clinical picture is pain, lacrimation, and blepharospasm. A drop of topical anesthetic is often necessary to facilitate examination. A fluorescein strip applied to the eye will usually reveal diffuse corneal staining when viewed with the aid of magnification and a black light. A drop of antibiotic should be instilled and a firm patch applied after the patient has been examined by the doctor. Sometimes a drop of 2% homatropine is helpful in relieving the pain of ciliary spasm. The patient should use his ophthalmologist or optometrist for follow-up care, and before he resumes the use of his contact lenses.

Sometimes the eye will receive a blow which does not produce an abrasion but which may produce hemorrhage in the interior of the eye. Bleeding in the anterior chamber (hyphemia) is sometimes evident. A difference in pupil size between the injured and non-injured eye is also often apparent. Although all cases of blunt injury should be referred to a medical officer, immediate treatment consists of making the patient as comfortable as possible after removing any dirt or foreign particles from the lids or eye. If there is considerable swelling of the eyelids, cold compresses should be applied to the affected area. If an eye is extruded after a severe injury, do not attempt to push it back in. Cover the eyes with a moist dressing and move the patient by stretcher for emergency treatment.

FOREIGN BODIES (DEEP). Deep foreign bodies or foreign bodies which have penetrated in or around the structure of the eyeball are not always easy to diagnose. It is possible for a tiny particle of metal propelled at high speed to enter the eyeball or orbital structures with only a suspicion of its existence. An X-ray series of the skull is the easiest way to ascertain the presence of these particles.

If a large wound exists and the eye is leaking aqueous, place the patient on his back immediately and apply loose dressings to both eyes. Ready the patient for transport by litter for surgical help. Under no circumstances should you try to remove an imbedded or penetrated foreign body. If a protruding foreign body exists, such as a pencil, a toothpick, a spear of glass, etc., again do not attempt to remove it. Instead place a cone or paper cup over that eye and tape the cup in place with scotch or plastic tape. Apply a loose dressing to the other eye as well before transporting the patient.

FOREIGN BODIES (SUPERFICIAL). The treatment for superficial foreign bodies depends on the type of material present on the eye. A general rule is to irrigate the eye in an attempt to dislodge the particulate material. Inert foreign bodies, such as coal, glass, plastic, aluminum and lead frequently require no treatment if they are producing no discomfort. Reactive foreign bodies, even though they are superficial, must be removed. Reactive foreign bodies include iron, steel, copper, wood, and thorns. Removal procedures include irrigation, topical anesthesia, and use of a "Q-tip" or other implement. The cornea should not be stained before the foreign body is removed. If it is concluded that the material is imbedded firmly in the tissue, refer the patient to a doctor who is knowledgeable in the ocular procedures required. An antibiotic and sometimes an anodyne may be ordered by the attending physician. Usually a firm dressing over the injured eye is ordered to help healing and to reduce discomfort.

Sometimes superficial foreign bodies lodge on the undersurface of the eyelids. Eversion of the lower lid to examine the conjunctiva is relatively simple. To evert the upper lid, have the patient look down at his feet, grasp the eyelashes with the thumb and finger of one hand and pull the lid gently away from the eyeball. At the same time place an applicator stick horizontally midway across the outer surface of the lid, and pull the lid up and over the applicator. This will expose most of the conjunctival surface of the upper lid. Irrigation or use of a cotton-tipped applicator will facilitate removal of any material which may be lightly imbedded in the conjunctiva.

OTHER OCULAR EMERGENCIES

EXTREME EYE PAIN. A symptom of this type is usually serious and you should do little except refer the patient as soon as possible to a medical officer. However, one can suspect an attack of acute narrow-angle glaucoma when there is severe ocular pain. The pain often radiates towards the back of the head and the patient may have nausea. Vision will be blurred due to a cloudy cornea and the pupil is dilated. The eye will appear inflamed. The eye will feel hard on palpation due to the high intraocular pressure. If an ophthalmologist is not available and you are absolutely certain that the patient has acute glaucoma 4% pilocarpine or 1/4% eserine salicylate should be instilled immediately and repeated every 15 to 30 minutes for several hours. Other systemic procedures should be started as soon as possible by a medical officer or ophthalmologist. Acute glaucoma should be differentiated from conjunctivitis which is not nearly so painful and which usually has a purulent discharge, and acute iritis which has a contracted pupil and a muddy-looking iris. Acute glaucoma, conjunctivitis, and iritis all present a "red eye" and to that extent are similar. There are other ocular diseases which cause a painful eye and are not generally in the realm of first aid.

SUDDEN LOSS OF VISION. This symptom is most often due to an occlusion of the central retinal artery or vein, retinal detachment, or hemorrhage. These patients should be referred for immediate care.

MEDICAL RECORDS IN AN OCULAR EMERGENCY

Frequently in the excitement of an ocular emergency, appropriate entries into the health record are overlooked. The patient's health records may not be readily available, disposition or referral of the patient is handled often by a hurried telephone conversation, etc. Once the patient has been stabilized, it is essential that you record the patient's name and identification data, a brief history describing what happened to the patient and when, and a description of the treatment and disposition of the patient. If necessary record this on a blank Form 600 for later filing in the patient's health record. Be sure the form is dated and signed.

One final note: It is not always possible to take a patient's visual acuity when the patient is in distress. However, where possible, record an estimate of the patient's visual acuity, for this may have medicolegal significance later, especially in the case of civilian workers.

EXERCISE 25

Answer the following questions in the spaces provided.

1. What is the immediate first aid treatment for most chemicals spashed into the eyes? ______________________________

____

2. What chemicals require that you not use the treatment explained in answer to question No. 1? ______________________________

____

3. Which requires the longer treatment, acid or alkali burns? Why?

4. Bleeding into the anterior chamber of the eye is a condition called

______________________________.

5. If a medical emergency arrives in the clinic with the diagnosis of acute glaucoma, would the proper emergency treatment include the instillation of a miotic or mydriatic? ______________________________.
How long and how often should this be administered initially? ______________

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AFM 160-17 INSERT

The next several pages have been taken from AFM 160-17, Examination Techniques. In class, you have been taught how to use different instruments for similar procedures. However, in clinical practice, as well as in the last block of this course, you will be expected to know and use all procedures on each instrument. This insert will assist you in understanding how each procedure fits in with all of the tests performed on the same instrument. When you prepare for your end of block review, study the instrument procedure by procedure instead of studying the procedure instrument by instrument.

Chapter 3

EYE EXAMINATION

SECTION A—OCULAR HISTORY AND EXAMINING TECHNIQUES

Ocular

3-1. Ocular History. A history of any ocular disease, injury, operation, medication, loss of vision, diplopia, and/or the use of glasses will be obtained. An attempt will be made to elicit any pertinent family history, such as, a history of glaucoma, retinitis pigmentosa, cataracts, and maternal lues.

3-2. Examination Techniques. External and ophthalmoscopic examinations of the eyes are required on all original examinations, and wherever otherwise indicated. Contact lenses will not be permitted to be worn during any part of the eye examination, including visual acuity testing, and it is essential that such lenses not be worn for 21 days preceding examination. The strength of contact lenses which an examinee may possess will not be accepted as his refractive error, nor will it be entered as such in item 60, SF 88. The general examination will include the following specific points:

a. General External Examination. Examination of the orbits to determine any bony abnormality or facial asymmetry should be made; the position of the eyes should be determined. Note any exophthalmos, enophthalmos, or manifest deviation of the visual axes.

b. Ocular Motility. Observation of gross ocular motility to determine the presence or absence of nystagmus or nystagmoid movements and the concomitant movement of the eyes in the six cardinal directions, right, left, up and to the right, up and to the left, down and to the right, down and to the left.

c. Lacrimal Apparatus. Presence of epiphora or discharge, position of the puncta, pressure over the lacrimal sac to determine if this produces any discharge from the puncta.

d. Lids. The presence of ptosis, the position of the lashes, inversion or eversion of the lids, the presence of any evidence of inflammation at the lid margins, and the presence of any cysts or tumors.

e. Ocular Tension. Ocular tension by digital palpation is inaccurate. Intraocular tension will be determined on all examinees 39 years of age or older or earlier if indicated by clinical history. This examination will be performed by a physician, optometrist, or technician who has received instruction in the proper performance and interpretation of this test.

f. Pupils. Size, shape, and equality of the pupils, direct consenusal, and accommodative pupillary reactions will be recorded and investigated.

g. Conjunctiva. Palpebral and bulbar conjunctiva will be examined by eversion of the upper lid, depression and eversion of the lower lid, and by direct examination with the lids separated manually as widely as possible.

h. Globe. The cornea, anterior chamber, iris, and crystalline lens will be examined by both direct and oblique examination. The cornea will be examined for clarity, discrete opacities, superficial or deep scarring, vascularization, and the integrity of the epithelium. Examine the anterior chamber for depth, alteration of the normal character of the aqueous humor, retained foreign bodies. Examine the irides for evidence of abnormalities, anterior or posterior synechiae, or other pathologic changes. The crystalline lens will be examined for evidence of clouding or opacities.

i. Ophthalmoscopic Examination. The media will be examined first with a +6.00 diopter ophthalmoscopic lens at a distance of approximately 18 to 21 inches from the eye. Any opacity appearing in the red reflex on direct examination or on movement of the eye will be localized and described. Examine the fundus with the strongest plus or weakest minus lens necessary to bring the optic nerve into sharp focus. Particular attention will be paid to the color, surface, and margin of the optic nerve, to the presence of any hemorrhages, exudates, or scars throughout the retina, to any abnormal pigmentation or retinal atrophy, to any elevation of the retina, and to the condition of the retinal vascular bed. The macula will be specially examined for any changes. Note any abnormalities observed.

SECTION B—REFRACTION

3-3. Use of Cycloplegics:

a. When required. Determine refractive error under cycloplegia in an original examination for flying training and Air Force Academy. Cycloplegics will not be instilled in the eyes until all other ophthalmologic examinations, except ophthalmoscopy, have been completed, nor will such drugs be used in the presence of infection, evidence of increased intraocular tension, or other contraindication.

b. Procedure. One drop of 4 or 5 percent solution of homatropine, or one percent cyclopentolate HCl

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will be instilled in each eye, repeated every 5 minutess until three drops have been instilled in each eye. Determine the refractive error one hour after the last drop of homatropine, or 20 minutes after the last drop of cyclopentolate has been instilled in each eye. Determine refractive error by retinoscopy in conjunction with subjective findings under cycloplegia. The refractionist will report what he determines to be the true refractive error. An emmetropic eye will be indicated by "plano" or "zero."

c. Strength of Corrective Lenses. If the visual acuity of an applicant for commission is not 20/20 in each eye, the strength of lenses which offer him the best correction will be determined and recorded. In all other cases where the visual acuity is found to approach maximum allowable limits, the strength of lenses which offer him the best correction will be determined and recorded.

3-4. Vision Test Apparatus, Near and Distant (VTA-ND). The vision testing stereoscope, Stock No. 6515-299-8048, combines the testing of several visual functions. It is the test of choice and, when available, will be used in all examinations.

a. Additional Vision Tests Required for Flying:

(1) Refraction.

(2) Accommodation.

(3) Color vision.

(4) Field of vision.

(5) Red lens test.

(6) Cover test.

(7) Near point of convergence.

(8) Intra-ocular tension.

b. Operational:

(1) One examinee will be tested at a time with one instrument. The examinee observes a series of test slides, some of which test his distance vision, others his near vision. The examiner will ask standard questions while the examinee is observing each slide and will determine his instrument score from the answers to these questions. The visual functions tested are vertical and lateral phoria at distance and near, right and left eye acuity at distance and near, and depth perception at distance.

(2) The instrument may be adjusted for individual differences in eye height by lifting or pressing on the bar handle at the back. (See figure 3-1). The brake lock lever at the right may be tightened to prevent any change in elevation, but normally is tightened just enough to permit change in elevation by slight pressure on the handle. A plastic cover is placed over the instrument when it is not in use.

(3) The distance slides are in the large drum rotated by crank F (for "far") into any of eight positions. The near slides are in the small drum, rotated by crank N (for "near") into any of the five positions. A spring stop holds each drum accurately at any position. At each position a different test slide will be presented. The distance slides are viewed by the examinee at a slightly downward angle, and the near slides at a greater downward angle. Each drum has a light inside, both operated by a single switch on the base of the instrument at the right. A small ruby window in the right side of the instrument shows when the lights are on.

(4) The viewing box is tipped up for the far slides or down for the near slides by means of the loop handle under it. The change can be made from one position to the other without disturbing the head position (except for presbyopes while wearing bifocal spectacles) of the examinee. Inside the viewing box an occluder may be turned to either side to block the view of either eye. It is operated by means of the handle under the box.

(5) In addition to the vision tester itself, the equipment includes one demonstration device, answer key, and a supply of record cards.

(6) The instrument and the auxiliary equipment will be placed on a substantial table 28 inches to 30 inches high with knee room beneath and at least several square feet top-surface area. Chairs should be straight and not inclined backward. The vision tester is connected by means of its electric cord to a 110-120 volt outlet (a. c. or d. c.).

c. Instrument Maintenance. Test slides may be removed for replacement when necessary. Lifting the lid of the instrument gives access to the slides in the far drum. Slides in the near drum are reached by withdrawing the pin stop, which limits the downward movement of the viewing box, and swinging the box to a secondary stop provided for that purpose. Bulbs should be dusted occasionally and should be replaced if they appear blackened. A slight counterclockwise rotation of the external portion of the light sockets releases the entire bulb assembly so that it may be withdrawn from the instrument. If the bulb needs to be replaced, slide the metal cap off the bulb before removing it from the socket. When a new bulb is screwed into the socket, it must be positioned precisely as before. The proper position for the bulb can be ascertained by observing the relationship between the support wire and the slot in the socket assembly in the case of the original bulb. (When the bulb is being inserted in its socket, the socket assembly should be held so that the slot is at 7 o'clock and the bulb placed

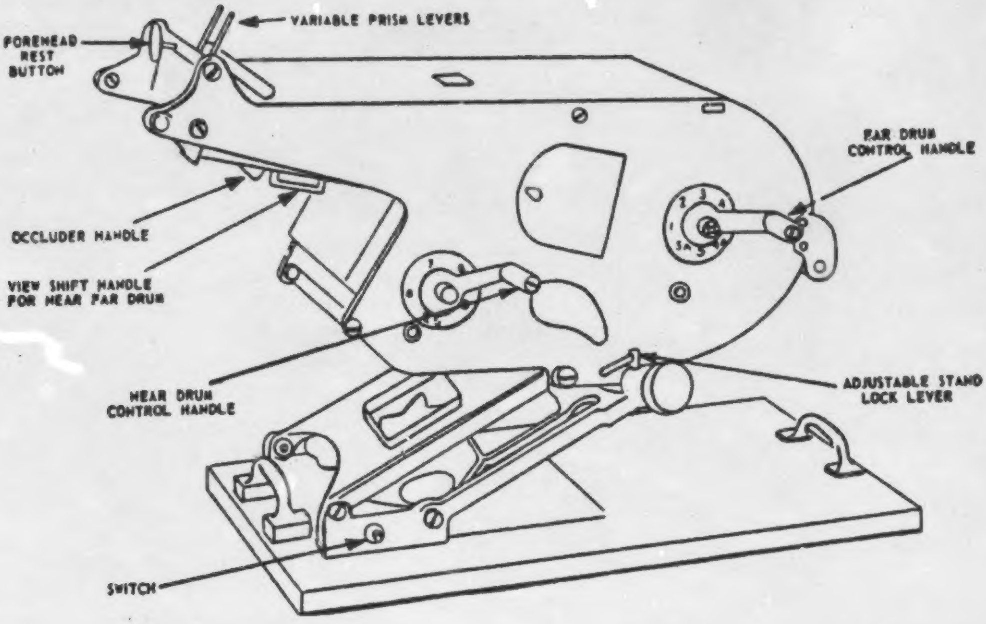


Figure 3-1. Vision Test Apparatus, Near and Distant (VTA - ND).

so that the filament support is located between the 1 and 5 o'clock positions. The metal cap should be placed over the bulb with the bar at approximately 3 o'clock.) Each cap is stamped on the end with the letter N or D. The cap marked N is for the lamp in the near drum and the one marked D is for the distance drum. These caps control the evenness and intensity of illumination and must always be used in their proper place.

d. Adjustment of Instrument. The examinee will sit before the instrument and will bring his chair under the table as far as is comfortable. The chair must be squarely facing the instrument. The examiner will adjust the height of the instrument and the examinee will lean his forehead against the headrest. In the correct position the examinee is looking through the center of the viewing lenses. When the viewing box is lowered to the near slides, he should not have to move his head (except for presbyopes while wearing bifocal spectacles); he still looks through the center of the viewing lenses. The center line of vision for the distance tests is not parallel with the top of the instrument, but at a slight downward angle directly in line with the main hinge of the viewing box and the shaft of the big drum. The examinee's eyes should be centered on this line. For the near tests, the center line of vision is in line with the main hinge on the viewing box and the shaft of the small drum, and the examiner sits on the right side of the instrument facing slightly toward the examinee. The examiner must watch constantly to see that the examinee's forehead is against the headrest, that both of his eyes are kept open without squinting, and that his head is not tilted.

e. Test Sequence:

(1) The tests are given in the order shown on table 3-1.

TABLE 3-1. Test Sequence.

Name of test	Drum	Position No. and slide No.
Far vertical phoria	Far	1.
Far lateral phoria	do	2.
Far acuity	do	3 and 4 or their alternates 3A, 4A.
Depth perception	do	5 or its alternate 5A.
Near vertical phoria	Near	6.
Near lateral phoria	do	7.
Near acuity	do	8 and 9.

(2) Tests 1 to 5 are in the back or "far" drum controlled by crank F.

(3) The near tests are on the front or "near" drum controlled by crank N. These tests will be given with the viewing box in the lower position.

f. Recording of Results. Each examinee will make an instrument score on each test. This score is a simple number or letter that indicates his performance on the machine. This instrument score is not a numerical measure of the visual ability tested. For example, in the vertical phoria test a score of 9 is not superior to a score of 1, and a score of zero does not mean complete absence of the ability tested. The scoring key attachment 3 gives the correct or true score for each instrument score. The "true score" will be entered on SF 88.

g. Test Procedure. If an examinee has correcting glasses, he will first take the entire series of tests without his glasses and then repeat the entire series with his glasses.

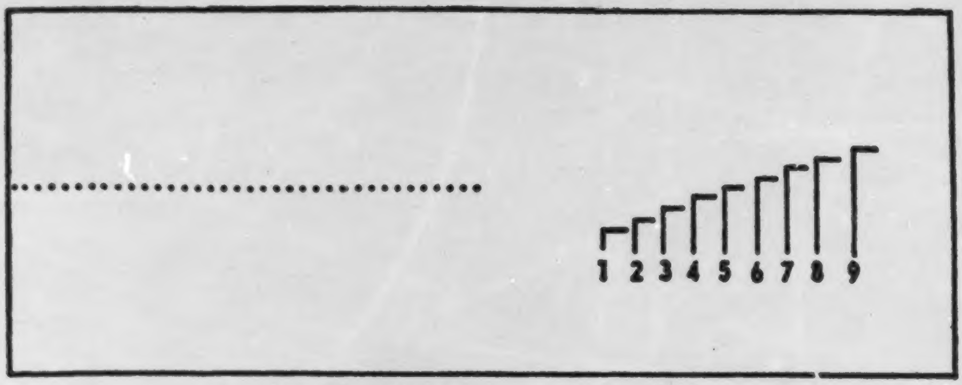
(1) Drum position 1, far vertical phoria (figure 3-2):

(a) The examiner will place the occluder in the midposition so that it does not block either eye and instructs the examinee to put his head against the head rest. He then asks the standard questions: "DO YOU SEE A WHITE DOTTED LINE? DO YOU SEE A ROW OF NUMBERED STAIRSTEPS? WHERE IS THE DOTTED LINE IN RELATION TO THE NUMBERED STEPS?" If the examinee says no to the first or second question, the examiner will put the occluder before the left eye and ask, "DO YOU SEE SOME STAIRSTEPS?" Then with the occluder before the right eye he will ask, "DO YOU SEE A WHITE DOTTED LINE?" With the occluder in the midposition he then asks, "NOW DO YOU SEE BOTH THE DOTTED LINE AND THE STAIRSTEPS?" If the examinee says no to any of these three questions, the test will be discontinued. If he says yes, the standard question will be repeated. The instrument score is the number (1-9) that the examinee answers. If the dotted line is below step 1, the score is zero, if above step 9, the score is 10. If the test is discontinued because of failure to see either the dotted line or the stairsteps, the score is X. Caution: All answers of 1, 2, 8, or 9 will be verified by asking, "THE DOTTED LINE IS AS HIGH AS THE TOP (OR BOTTOM) OR THE STAIRSTEPS?"

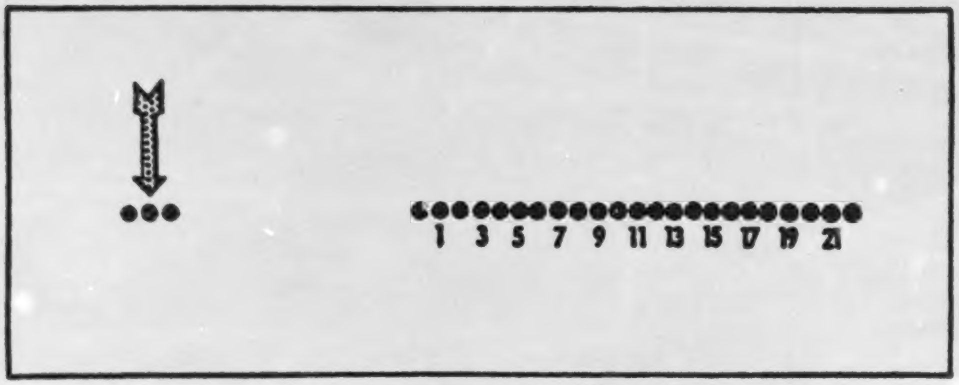
(b) Detection of Malingers. It would be possible for the examinee to feign a normal phoria if he knew that a score of 5, for example, is normal. To avoid this, an auxiliary device is provided by means of which the examiner can lower either the right or the left eye image. This device is known as the variable prism. Its two control handles are shown in figure 3-1. The correct score and the only score recorded is that obtained when both control handles are pushed inward as far as they will go. This is known as the scoring position. Moving the left handle outward from this position moves the left eye image downward and outward. Similarly, moving the right handle outward moves the right eye image downward and outward. The maximum amount of downward shift provided by each control corresponds to four scale divisions. Moving the right handle outward to its extreme position therefore will change the apparent location of the dotted line from step 1 to step 5, for example, from 6 to above 9, etc. Moving the left control handle outward to its extreme position similarly will change the apparent location of the dotted line from step 5 to step 1, or from step 8 to step 4, etc. The examiner varies the location of the right or left control handle, each time asking the examinee to report the location of the dotted line. Only one of these answers, that is, the answer obtained when both handles are in the scoring position, gives the examinee's score on the test.

(2) Drum Position 2, Far Lateral Phoria (figure 3-2):

(a) The procedure for this test is similar to that for vertical phoria. The standard question is, "TO WHICH NUMBER DOES THE ARROW POINT?" If the examinee says it does not point to any number or is between two numbers, the examiner will ask, "TO WHICH NUMBER IS IT CLOSEST?" If the examinee does not see the arrow or does not see the numbers, the procedure will be as described in the previous test. If the examinee says that the arrow moves over a wide range, the examiner will say, "LOOK CLOSELY AT THE CHECKER-



TEST 1—FAR VERTICAL PHORIA



TEST 2—FAR LATERAL PHORIA

Figure 3-2. Far Phoria Tests.

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BOARD PATTERN OF THE ARROW." If the arrow continues to move, the examiner will cover and then uncover the right eye with the occluder, saying, "LOOK CLOSELY AT THE ARROW." "TELL ME WHERE IT IS WHEN YOU FIRST SEE THE NUMBERED DOTS." The test will be discontinued if the examinee cannot see both the arrow and the numbers at the same time. Failure to see either the arrow or the numbers will be scored X as in the previous test. The instrument score is the number (1 through 21) that the examinee answers. The score is zero if the arrow is pointing to the left of 1. The score is 22 if the arrow is to the right of 21. Caution: If the examinee answers that the arrow "points to the second one," the examiner should verify that he means the dot between number 1 and number 3.

(b) Detection of Malingers. By means of the variable prism previously mentioned the right and left eye images can both be shifted outward a maximum of seven dots. To produce this outward shift without a downward shift, in this test both control handles will be moved outward simultaneously the same distance. When both handles are moved as far out as they go, the apparent position of the arrow is moved seven dots to the left giving a score seven below the true score. As in the previous test, the correct score and the only score recorded will be that obtained when the control handles are in the scoring position. That is when both are pushed inward as far as they wil go.

(3) Drum Positions 3 and 4 or 3A and 4A, Far

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Acuity (figure 3-3):

(a) In this test the examiner must remember to occlude the left eye when the right is tested and vice versa, whereas the previous test was given with the occluder in the mid- position. The prism control handles will be in the scoring position. Slide 3 and its alternate, slide 3A, contain the smaller letters, slide 4 and its alternate 4A, the larger ones. The larger letters are used only if the examinee cannot read correctly seven of the ten largest letters on slide 3 or its alternate, 3A. (Alternate slides are provided in case the examinee has memorized the order of the letters on a line which he cannot actually read.) On slides 3 and 3A, there are 20 letters of each size. Only 10 of the 20 letters of each size need be used. Thus, the examiner may ask the examinee to read lines 5 or 5A, 6 or 6A, etc.

(b) The examiner will say, "READ THE LETTERS ON LINE 5 AT THE TOP OF THE CHART." (Line 5A may be used instead.) If more than three errors are made, the test will continue with the larger letters on slide 4 or slide 4A. If three or less errors are made in line 5 or 5A, the examiner will say, "LOOK AT THE SMALLER LINES OF LETTERS ON THE LEFT AND THE STILL SMALLER ONES ON THE RIGHT. WHAT IS THE SMALLEST LINE YOU CAN READ EASILY?" From this point on the examiner may proceed in any way he wishes to determine the smallest line of letters which the examinee can read with not more than three errors in 10 letters. (TO OBTAIN A SCORE FOR ANY GIVEN LINE OF 10 LETTERS THE EXAMINEE MUST CALL OFF CORRECTLY 7 OR MORE LETTERS IN THAT LINE. ALTERNATELY EXPRESSED THE EXAMINEE WILL BE ALLOWED TO MAKE 3 ERRORS IN ANY LINE OF 10 LETTERS AND STILL RECEIVE THE SCORE FOR THAT LINE.) The examinee's instrument score on this test will be the number of the smallest line of letters on which not more than 3 errors in 10 are made. Only 10 letters of each group need to be used unless the examiner suspects malingering or wishes to verify the examinee's final score by having him read a second 10 letters of the same size.

(c) If the examinee cannot read lines 5 or 5A with three or less errors, the examiner will determine his acuity score using slide 4 or its alternate, slide 4A. There are four sizes of letters on this chart corresponding to instrument scores 1 to 4. The lines are not numbered on this slide. The top line represents a score of 1. The second and third lines from the top represent as score of 2. The fourth lines represents a score of 3 and the bottom line a score of 4. The examiner should have the examinee start with the top line of 3 letters. IF HE MAKES 1 ERROR OR NO ERRORS ON THE TOP LINE, HE CONTINUES WITH THE SMALLER LETTERS UNTIL HE HAS MADE 4 OR MORE ERRORS IN READING THE 10 LETTERS OF A SIZE. (TO OBTAIN A SCORE FOR ANY GIVEN SIZE OF 10 LETTERS THE EXAMINEE MUST CALL OFF CORRECTLY 7 OR MORE LETTERS IN THAT SIZE. ALTERNATELY EXPRESSED THE EXAMINEE WILL BE ALLOWED TO MAKE 3 ERRORS IN ANY SIZE OF 10 LETTERS AND STILL RECEIVE THE SCORE FOR THAT SIZE.) The instrument score is given by the letter size for which not more than 3 errors in 10 are made; an exception is made for the top line of 3 letters, of which two must be read correctly to give a score of 1. If more than 1 error is made, the instrument score is 0.

(4) Drum positions 5 or 5A, Binocular Fusion and Depth Perception (figure 3-4):

(a) Fusion Test. Before giving this test the examiner will make sure that the occluder is in the midposition and the prism control handles are in the scoring position. The purpose of this test is to determine whether the slightly different test targets presented to the right and to the left eye are combined into a single image; they are seen double, that is side by side or one above the other; or the target presented to one eye is not seen.

(b) If the examinee has normal binocular (two-eyed) vision, he will see at the left of the slide a single arrow with both a head and a tail ((1) in figure 3-5). To make sure that the examinee actually has normal binocular vision, the examiner will ask him to describe what he sees, and check the truthfulness of the answers by covering one eye of the examinee with the occluder. When the right eye is covered, the tail of the arrow should disappear. When the left eye is covered, the head of the arrow should disappear. If either of the following abnormal answers are given when the examinee is allowed to use both eyes (occluder not over either eye), the examiner will count the fusion test as failed.

1. Double Vision. The examinee reports that he sees two arrows side by side as in (2) in figure 3-5, or that he sees two circles, one above the other as in (3) in figure 3-5. Before failing examinee the examiner will check to see that prisms are in scoring position.

2. Suppression. When allowed to use both eyes, the examinee sees only the head or only the tail

Acuity (figure 3-3):

(a) In this test the examiner must remember to occlude the left eye when the right is tested and vice versa, whereas the previous test was given with the occluder in the mid- position. The prism control handles will be in the scoring position. Slide 3 and its alternate, slide 3A, contain the smaller letters, slide 4 and its alternate 4A, the larger ones. The larger letters are used only if the examinee cannot read correctly seven of the ten largest letters on slide 3 or its alternate, 3A. (Alternate slides are provided in case the examinee has memorized the order of the letters on a line which he cannot actually read.) On slides 3 and 3A, there are 20 letters of each size. Only 10 of the 20 letters of each size need be used. Thus, the examiner may ask the examinee to read lines 5 or 5A, 6 or 6A, etc.

(b) The examiner will say, "READ THE LETTERS ON LINE 5 AT THE TOP OF THE CHART." (Line 5A may be used instead.) If more than three errors are made, the test will continue with the larger letters on slide 4 or slide 4A. If three or less errors are made in line 5 or 5A, the examiner will say, "LOOK AT THE SMALLER LINES OF LETTERS ON THE LEFT AND THE STILL SMALLER ONES ON THE RIGHT. WHAT IS THE SMALLEST LINE YOU CAN READ EASILY?" From this point on the examiner may proceed in any way he wishes to determine the smallest line of letters which the examinee can read with not more than three errors in 10 letters. (TO OBTAIN A SCORE FOR ANY GIVEN LINE OF 10 LETTERS THE EXAMINEE MUST CALL OFF CORRECTLY 7 OR MORE LETTERS IN THAT LINE. ALTERNATELY EXPRESSED THE EXAMINEE WILL BE ALLOWED TO MAKE 3 ERRORS IN ANY LINE OF 10 LETTERS AND STILL RECEIVE THE SCORE FOR THAT LINE.) The examinee's instrument score on this test will be the number of the smallest line of letters on which not more than 3 errors in 10 are made. Only 10 letters of each group need to be used unless the examiner suspects malingering or wishes to verify the examinee's final score by having him read a second 10 letters of the same size.

(c) If the examinee cannot read lines 5 or 5A with three or less errors, the examiner will determine his acuity score using slide 4 or its alternate, slide 4A. There are four sizes of letters on this chart corresponding to instrument scores 1 to 4. The lines are not numbered on this slide. The top line represents a score of 1. The second and third lines from the top represent as score of 2. The fourth lines represents a score of 3 and the bottom line a score of 4. The examiner should have the examinee start with the top line of 3 letters. IF HE MAKES 1 ERROR OR NO ERRORS ON THE TOP LINE, HE CONTINUES WITH THE SMALLER LETTERS UNTIL HE HAS MADE 4 OR MORE ERRORS IN READING THE 10 LETTERS OF A SIZE. (TO OBTAIN A SCORE FOR ANY GIVEN SIZE OF 10 LETTERS THE EXAMINEE MUST CALL OFF CORRECTLY 7 OR MORE LETTERS IN THAT SIZE. ALTERNATELY EXPRESSED THE EXAMINEE WILL BE ALLOWED TO MAKE 3 ERRORS IN ANY SIZE OF 10 LETTERS AND STILL RECEIVE THE SCORE FOR THAT SIZE.) The instrument score is given by the letter size for which not more than 3 errors in 10 are made; an exception is made for the top line of 3 letters, of which two must be read correctly to give a score of 1. If more than 1 error is made, the instrument score is 0.

(4) Drum positions 5 or 5A, Binocular Fusion and Depth Perception (figure 3-4):

(a) Fusion Test. Before giving this test the examiner will make sure that the occluder is in the midposition and the prism control handles are in the scoring position. The purpose of this test is to determine whether the slightly different test targets presented to the right and to the left eye are combined into a single image; they are seen double, that is side by side or one above the other; or the target presented to one eye is not seen.

(b) If the examinee has normal binocular (two-eyed) vision, he will see at the left of the slide a single arrow with both a head and a tail ((1) in figure 3-5). To make sure that the examinee actually has normal binocular vision, the examiner will ask him to describe what he sees, and check the truthfulness of the answers by covering one eye of the examinee with the occluder. When the right eye is covered, the tail of the arrow should disappear. When the left eye is covered, the head of the arrow should disappear. If either of the following abnormal answers are given when the examinee is allowed to use both eyes (occluder not over either eye), the examiner will count the fusion test as failed.

1. Double Vision. The examinee reports that he sees two arrows side by side as in (2) in figure 3-5, or that he sees two circles, one above the other as in (3) in figure 3-5. Before failing examinee the examiner will check to see that prisms are in scoring position.

2. Suppression. When allowed to use both eyes, the examinee sees only the head or only the tail

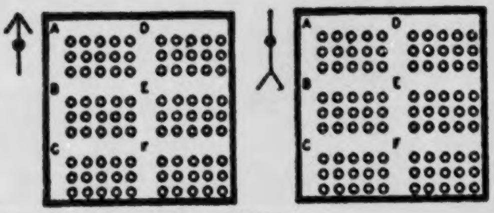
of the arrow (4) in figure 3-5.

(c) Depth Test:

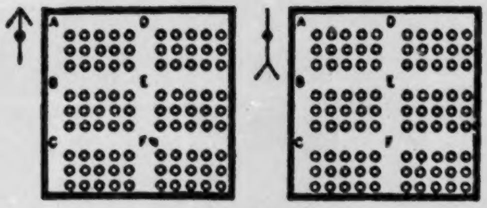
1. This test will be omitted if the examinee fails the fusion test, that is, if he exhibits either double vision or suppression. It will also be omitted if the examinee's score is 0,1,2,3, or 4 on the far-acuity test in either eye. A score of X will be given if the depth test is omitted.

2. In the entire battery of tests that for perception is the most difficult to give and interpret. This is, in part, because examinees who have normal perception of depth in situations to which they are accustomed may have to learn to see the apparent depth employed in this test. Consequently, although good scores can be accepted as evidence of normal binocular vision and normal depth perception, even complete failure on this test, unless supported by other evidence, is not necessarily indicative of poor depth perception. Therefore, to reduce to a minimum the number of "false failures," the examiner should not hurry through the demonstration and the practice period which precede the actual test. The depth slide used to test depth perception consists of a number of horizontal rows of cirlces, five circles in each row, one of which should appear slightly nearer to the examinee than the other four.

3. To explain the test, the examinee will first be shown a demonstration device consisting of a transparent plastic plate with four black circles on the rear surface, one in the front. As in the depth-perception test itself, one circle appears nearer than the other four. After the plastic demonstration model of the test has been shown, the examinee will be told to look into the instrument and his attention directed to group A, the three rows of circles in the upper left-hand corner of the square. The first group will be used to further explain the test and allow time for the perception of depth to develop. The top row of five circles in group A demonstrates a relatively large difference in depth, the middle row a moderate difference, the bottom row a small difference. Some examinee may not see any depth for the first minute or so, and in such cases the examiner must not hurry through the practice test. He may tell the examinee the correct answers to the three rows of group A and instruct him to look at each circle in turn until he can see that one of the five circles in each row is nearer to him than the others.



TEST 5



TEST 5A

Figure 3-4. Fusion and Depth Perception.

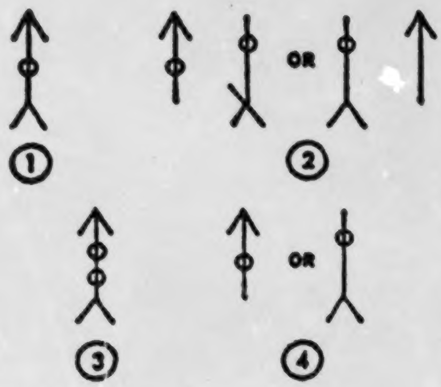


Figure 3-5. Binocular Vision Tests.

4. The examiner may use the occluder to demonstrate that with monocular (one-eyed) vision all the circles appear in the same plane, while with binocular (two-eyed) vision one may appear nearer than the other four. When the examiner is satisfied that the examinee actually sees depth in at least the top row, he may proceed to the actual test. This will be given without any help or hints from the examiner such as are used in the practice period. The examinee will be asked to indicate by number, counting from

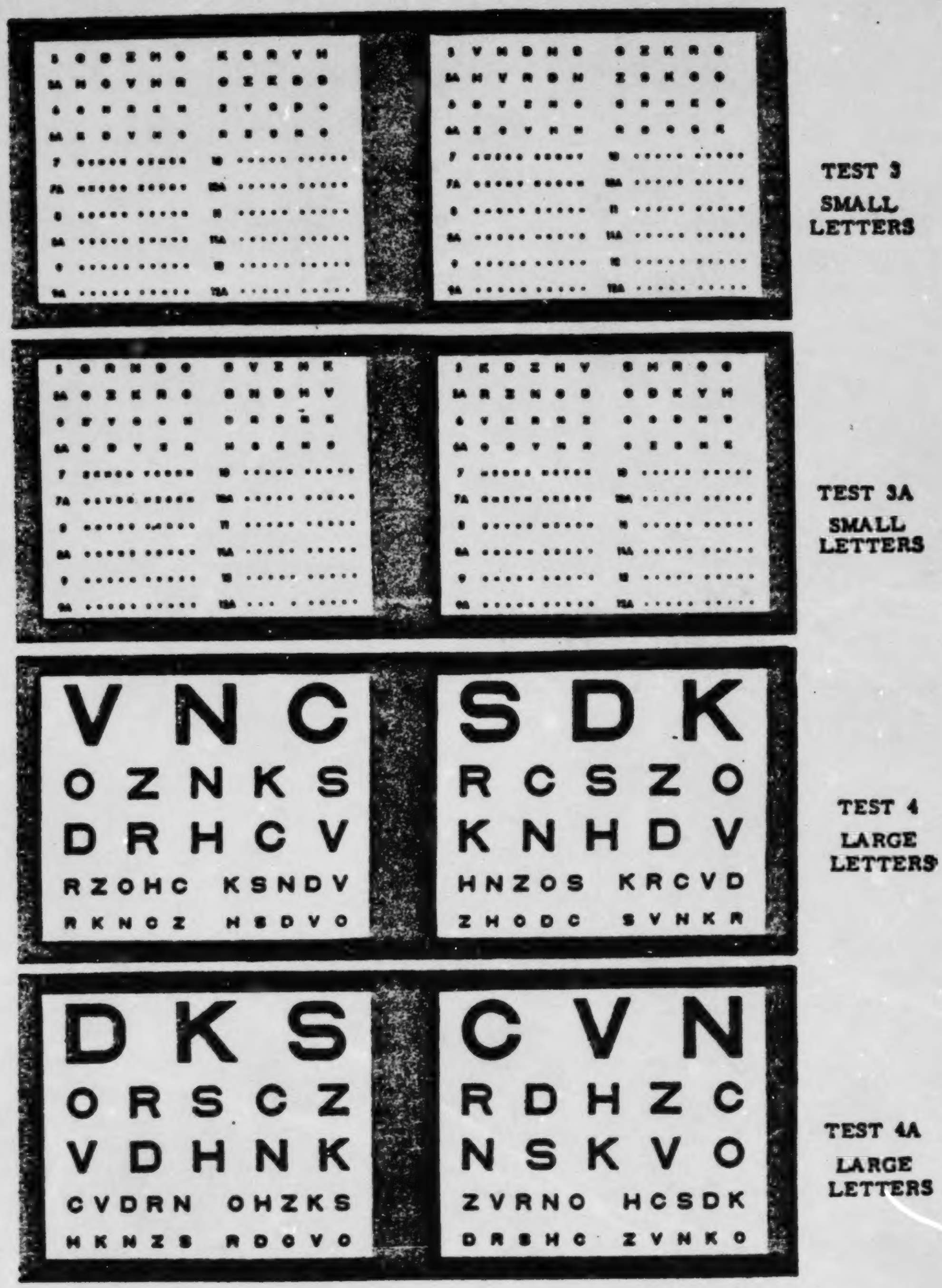
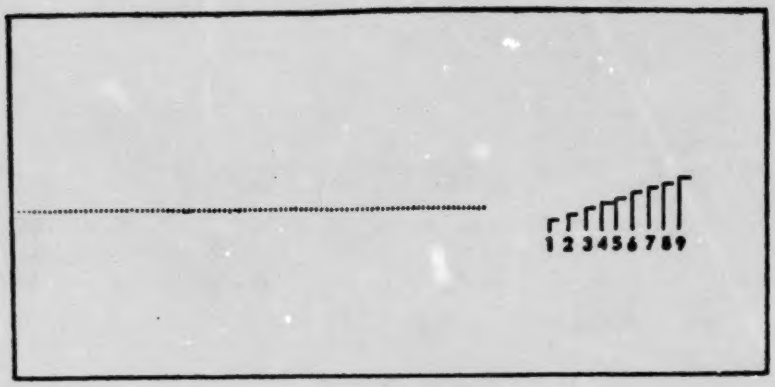
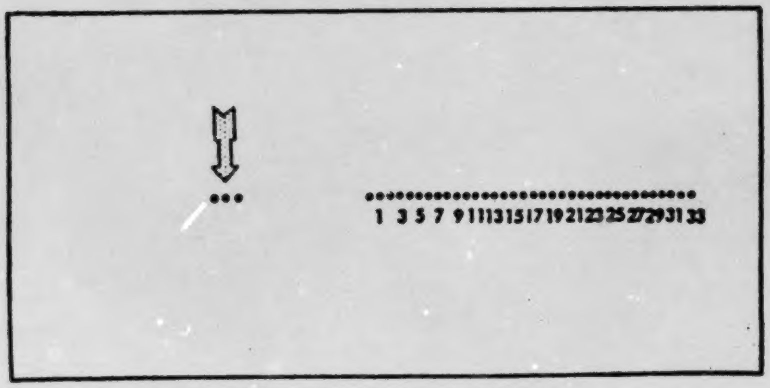

TEST 3
SMALL LETTERS
TEST 3A
SMALL LETTERS
V N C
O Z N K S
D R H C V
RZOHC KSNDV
RKNOZ HSDVO
S D K
R C S Z O
K N H D V
HNZOS KRCVD
ZHODC SVNKR
TEST 4
LARGE LETTERS
D K S
O R S C Z
V D H N K
CVDRN OHZKS
HKNZS RDCVO
C V N
R D H Z C
N S K V O
ZVRNO HCSDK
DRSHC ZVNKO
TEST 4A
LARGE LETTERS

Figure 3-3. Far - Letter Acuity.



TEST 6 - NEAR VERTICAL PHORIA



TEST 7 - NEAR LATERAL PHORIA

Figure 3-6. Near Phoria Tests.

"LOOK AT THE SMALLER LINES OF LETTERS ON THE LEFT AND THE STILL SMALLER ONES ON THE RIGHT. WHAT IS THE SMALLEST LINE YOU CAN READ EASILY?"

Examiner will continue testing to determine smallest line which examinee can read with not more than three errors in line of ten. Both right and left eye will be tested. Instrument score is the number of the smallest line read with not more than three errors.

4. F-4 (Or 4A alternate slide, scored the same) Far letter acuity (large letters)—Occluder before eye not being tested. If examinee cannot read line 5 in F-3 or F-3a with 3 or less errors for either right or left eye examiner will use this slide starting with largest letters and continuing until examinee fails one size of letters. If a score on F-3 or F-3a has been obtained for one eye, examiner will test only the failing eye on slide F-4 or F-4a.

Instrument score will be 1 if examinee can read two of the three largest letters, but misses more than three of the next size. Otherwise the score will be the scoring key number of the smallest size of 10 letters on which no more than three errors are made. These are alternate slides for F-3 and F-4 and will be administered and scored in the same manner.

5. F-5 (Or 5A alternate slide scored the same) Binocular fusion and depth perception—occluder in midposition. Prism control handles in scor-

left to right, which circle is nearer in the top, the middle, and the bottom row of group B. If all three answers are correct, the same questions will be asked for group C, group D, etc. The test will be discontinued when the examinee gives one or more incorrect answers in any one group beyond group B. (If one or more incorrect answers are given in group B, the examiner will repeat the practice session with group A, then have the examinee try group B again, followed by group C, etc., if correct answers are now given in Group B.) The score will be the letter of the last group in which no errors are made. If the first test group B is failed a second time, the score will be recorded as zero.

(5) Drum position 6, near vertical phoria (figure 3-6): The procedure for administering the near phoria test is the same as the procedure described above for the far vertical phoria test.

(6) Drum Position 7, Near Lateral Phoria (figure 3-6): The procedure is the same for the far lateral phoria test.

(7) Drum Positions 8 and 9, Near Acuity (figure 3-7): The procedure is the same as for the far acuity test.

(8) Acuity Test for Illiterates (figure 3-8):

(a) Measurement of the Visual Acuity of Illiterate Examinees. A slide for measuring the distant acuity of illiterate examinees may be substituted for one of the other acuity slides. This slide contains broken rings resembling the letter C, turned so that the opening is in one of the four directions, up, down, right, or left. There are seven different sizes of the broken ring character on the illiterate slide numbered 1, 2, 3, 4, 6, 7, and 9 on the scoring key. These lines are not numbered on the slide. In this test lines will not be skipped. The examinee will be required to read every line, starting with the large rings at the top and proceeding to successively smaller lines. As in the letter test, the instrument score will be the number of the lowest line on which breaks in at least seven of ten rings are correctly located.

(b) Right Eye Tested First. The occluder will be placed in front of the left eye and the prism control handles in the scoring position. The standard questions are, "DO YOU SEE THE THREE LARGE CIRCLES AT THE TOP? EACH CIRCLE HAS AN OPENING IN IT. WHERE IS THE OPENING IN THE FIRST ONE? IN THE SECOND? IN THE THIRD?" It may be necessary to raise the lid and point to individual rings to insure an accurate test. If the examinee appears to confuse right and left in reporting the location of the breaks, the examiner will ask him to begin the line again saying, "TELL ME WHETHER THE OPENINGS ARE AT THE TOP, AT THE BOTTOM, ON THE SIDE TOWARD ME (touching examinee's right arm), OR ON THE OTHER SIDE." If right and left are still confused, the examiner will substitute hand signals with examinee pointing in direction of openings on either side. Examiner will test on each successive line until one is failed. The left eye will be tested the same way (Examiner will change the occluder.)

(c) Instrument Score. Key score number for the last line passed will be recorded. On line 1 a passing score requires correct identification of the breaks of two of the three rings. Line 2 requires identification of three of the five rings. The remaining lines contain 10 rings and are failed if more than 3 are not identified correctly.

(9) Binocular Acuity Test (figure 3-9). Slides for distant or near binocular acuity are available and the procedure will be the same as for monocular vision except that the occluder is kept in the midposition.

(10) Summary, Questions, and Scoring:

(a) Distance Tests:

1. F-1 Vertical phoria far—Occluder in midposition.

Question—"DO YOU SEE A WHITE DOTTED LINE? DO YOU SEE A ROW OF NUMBERED STAIRSTEPS? WHERE IS THE DOTTED LINE IN RELATION TO THE NUMBERED STEPS?"

Instrument score is the number (1-9) given with prism handles in scoring position. If below step 1, record zero; above step 9, 10 is recorded. If both steps and dotted line are not seen at the same time, X is recorded.

2. F-2 Lateral phoria far—Occluder in midposition.

Question—"TO WHICH NUMBER DOES THE ARROW POINT?"

Instrument score is the number (1-21) given with prism handles in scoring position. If arrow points to left of 1, the score is zero; to right of 21, the score is 22. If arrow and numbered dots are not seen at the same time, X is recorded.

3. F-3 (Or 3A alternate slide, scored the same) Far letter acuity (small letters)—Occluder before eye not being tested, prism handles in scoring position. Examiner will test first right eye, then left eye.

Question—"READ THE LETTERS ON LINE 5 AT THE TOP OF THE CHART."

If three or less errors are made:

ing position.

Fusion Test

Question—"DO YOU SEE A LARGE SQUARE CONTAINING LETTERS AND CIRCLES? TO THE LEFT OF THE SQUARE WHAT DO YOU SEE? DESCRIBE IT."

Examiner should make certain examinee sees both head and tail of arrow with a single shaft passing through the circle.

Right eye is occluded.

Question—"WHAT DO YOU SEE NOW?"

Examinee should see only head of arrow.

Left eye is occluded.

Question—"WHAT DO YOU SEE NOW?"

Examinee should see only tail of arrow. If examinee does not pass the fusion test, depth test will be omitted and depth score recorded as X.

Depth Test

If examinee passes fusion test, examiner will continue with depth test—occluder in midposition.

Question—"WILL YOU LOOK IN THIS DIRECTION? THIS NEXT TEST WILL SHOW GROUPS OF CIRCLES LIKE THIS." (Demonstrator will be presented with slide which has single circle toward examinee.) "DO YOU SEE THAT THIS CIRCLE (point) IS CLOSER TO YOU THAN THE OTHERS? LOOK INTO THE INSTRUMENT AGAIN. IN GROUP A, LOOK AT THE TOP ROW OF CIRCLES. WHICH CIRCLE IS CLOSER TO YOU (COUNTING ACROSS THE ROW FROM THE A)?"

If the examinee does not answer immediately examiner will give him clues including the proper answer to this row, and rows 2 and 3 of group A. Making certain examinee keeps both eyes open, examiner continues with group B through F until one of the three lines in a group is failed. If examinee fails group B, training group A will be repeated and the examinee will test a second time in group B, continuing with the remainder of test if group B is passed.

Instrument score is zero if group B is failed the second time. Otherwise the examiner records the better score of the last group in which no errors are made.

(b) Near Tests. After the depth test the near point tests will be given, using the slides in the front drum. The examinee remains in position at the instrument and the examiner drops the viewing box to the near testing position, saying, "KEEP YOUR HEAD IN THE SAME POSITION." If the examinee is wearing bifocals, it may be necessary for him to tilt his head backwards slightly so that he can look through the "reading" portion of his bifocals.

1. N-6 Near vertical phoria—occluder in midposition.

Question—"NOW THE DOTTED LINE IS NEAREST LEVEL WITH WHICH STEP?"

Examiner will check for malingering and score as in F-1.

2. N-7 Near lateral phoria—occluder in midposition.

Question—"NOW THE ARROW POINTS TO WHICH NUMBER?"

Examiner will check for malingering and score as in F-2. Prism handles are then returned to scoring position.

3. N-8 Near letter acuity (small letters) occluder before eye not being tested. Test and score as in F-3 or F-3a.

4. N-9 Near letter acuity (large letters) occluder before eye not being tested. This test will be used if line 5 in N-8 is failed. Examiner will test and score as in F-4 or F-4a.

5. N-10 Space for optional slides.

(c) Illiterate Test:

1. Examiner will make certain occluder is in front of the left eye, prisms control handles in scoring position.

Question—"DO YOU SEE THE THREE LARGE CIRCLES AT THE TOP: EACH CIRCLE HAS AN OPENING IN IT. WHERE IS THE OPENING IN THE FIRST ONE? IN THE SECOND? IN THE THIRD?"

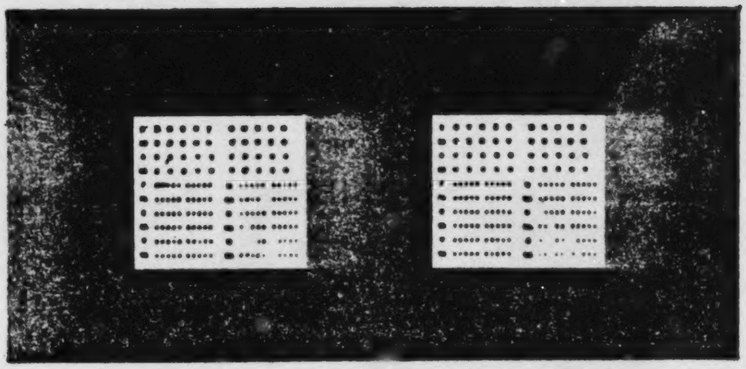
2. Instrument Score. Examiner will record the answer key score number for the last line passed. On line 1 a passing score requires correct identification of two of the three rings. Line 2 requires identification of three of the five rings. The remaining lines contain 10 characters and are passed if 7 of the 10 are correctly identified.

(d) Binocular Acuity. Occluder in mid-position—prisms in scoring position.

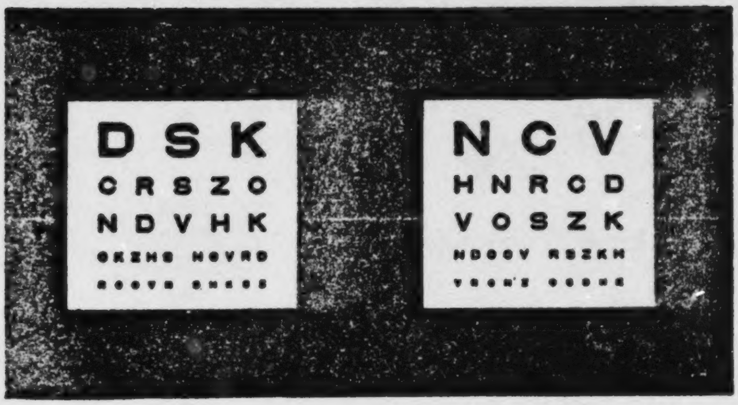
(e) Scoring Key. (See tables 3-2 and 3-3.) The tests are administered and scored in the same manner as the monocular acuity tests.

3-5. Distance Vision:

a. Procedure. If the VTA-ND is not available for vision testing, the following method will be used:

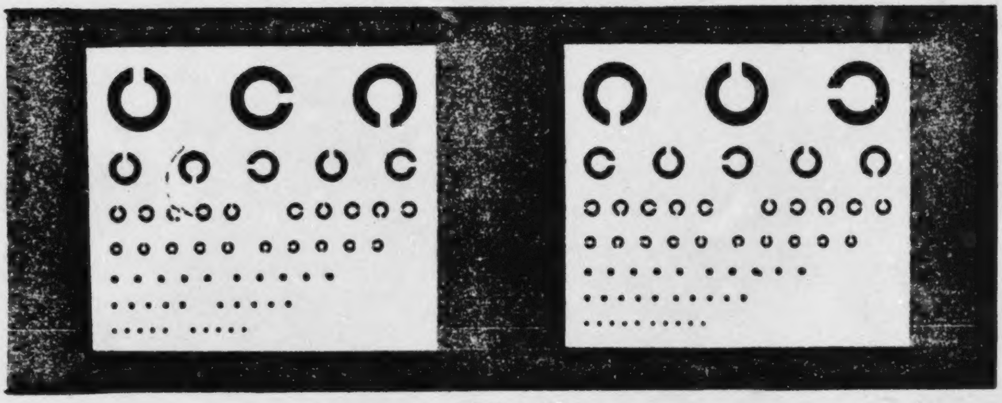


TEST 8 — SMALL LETTERS


D S K
C R S Z O
N D V H K
N C V
H N R C D
V O S Z K

TEST 9 — LARGE LETTERS

Figure 3-7. Near Letter Acuity.



TEST 4–S

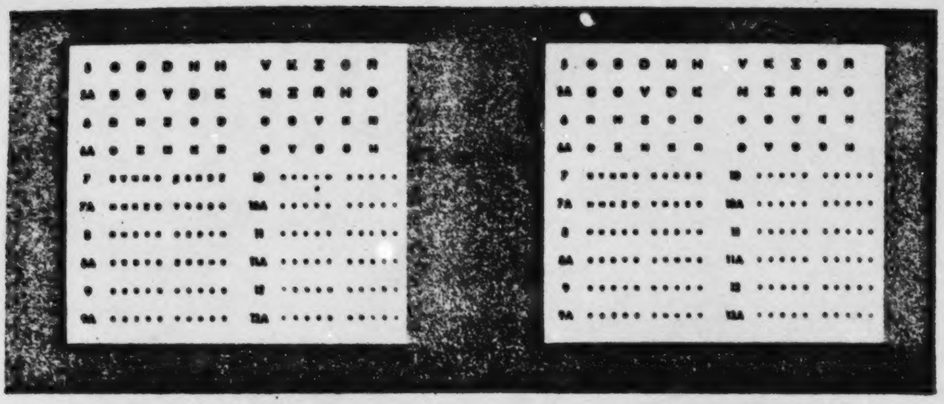
Figure 3-8. Far Ring Acuity - Illiterates.

SCORING KEY, VISION TEST APPARATUS, NEAR AND DISTANT VISION TESTING

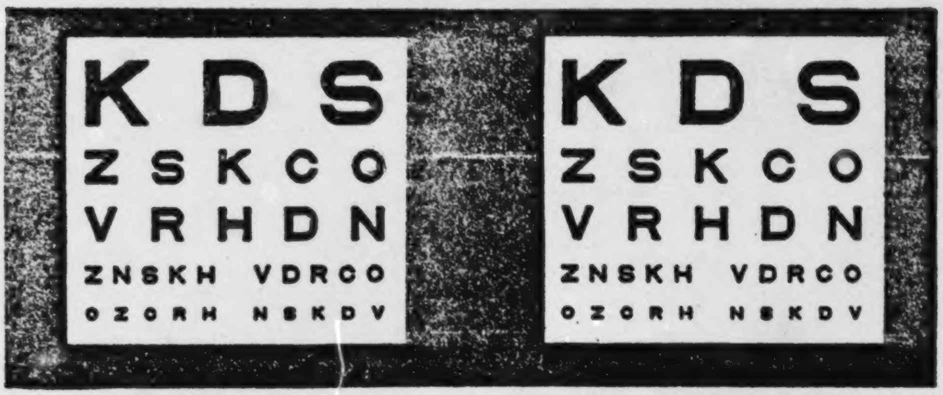
FAR TESTS					
Score		Test 3—Small letters		Test 3A—Small letters	
		Left eye	Right eye	Left eye	Right eye
20/50	5	CDZNO KSRVH	VHDNS OZKRC	CRNDO SVZHK	KDZNV SHROC
	5A	NCVHR OZKDS	HVRDN ZSKCO	OZKRC SNDHV	RZNCS ODKVH
20/40	6	CNRKH ZVSDO	DVZNC SRHKO	ZVCOH DRSNK	VKRNZ CODHS
	6A	KDVHO RZSNC	ZCVHN RDOSK	ODVZR HSKNC	ODVNR CZSHK
20/30	7	DVHCK OZNSR	KNZCO SRDHV	ZKHSO VCDRN	HSDRZ NCVOK
	7A	HNCDO ZKSRV	DZONV RCSKH	OCVDR HZSKN	RNZVH OKSCD
20/25	8	CDKRO SZVNH	KNDRS ZVCOH	HNVZS CKRDO	ZOVCX NRKDH
	8A	CDSVO ZHRNK	HKZSC NROVD	OSRNZ CDHKV	KNROH SDZCV
20/20	9	CVHSZ ORKDN	VZCHD KNRSO	RHCVN ODSZK	RHSDK ONCVZ
	9A	VHOKC SRNZD	CKROH SDZNV	ZHODC SVNKR	OSCHN RVKZD
20/17	10	DNVHS OKRCZ	KZSVN HCRDO	KRNHC OSDVZ	KNRZD OHVCS
	10A	ZDVOH CRSKN	ZHRSN OKVDC	NDZOC HVKSR	RKCVN OZDSH
20/15	11	ZHODC SVNKR	RCSNV KDHOZ	SCHZD VKNRO	KZODR HNSCV
	11A	VDKHO RSZNC	VDHON RCKZS	VDNSK ZHCOR	ZDCKN SVRHO
20/13	12	KHOZD CSNVR	ROKHZ NSCVD	CNDZK OHRVS	RVNSZ KCDOH
	12A	ZVSDO CHNRK	CRNDO SZVKH	HOCVZ SRNKD	CSNDO HRVKZ
		Test 4—Large letters		Test 4A—Large letters	
		Left eye	Right eye	Left eye	Right eye
20/400	1	VNC	SDK	DKS	CNV
20/200	2	OZNKS	RCSZO	ORSCZ	RDHZC
	2	DRHCV	KNHDV	VDHNK	NSKVO
20/100	3	RZOHC KSNDV	HNZOS KRCVD	CVDRN OHZKS	ZVRNO HCSDK
20/70	4	RKNCZ HSDVO	ZHODC SVNKR	HKNZS RDCVO	DRSHC ZVNKO

Test 5—Depth	Test 5A—Depth	Score		Test 4—S	Illiterate
				Left eye	Right eye
A B C D E F	A B C D E F*	20/400	1	URD	DUL
3 4 2 4 2 3	3 3 4 3 2 3	20/200	2	UDLUR	RULUD
2 3 4 2 4 3	2 4 2 2 3 2	20/100	3	ULDLU RURDL	LRRDR ULDRU
4 4 2 3 3 2	4 2 4 3 4 2	20/70	4	RUDRU DLDRL	LDLRU DURLU
		20/40	6	UDRLD LRDLU	DLRDR UDRLU
		20/30	7	RULDL URUDL	RUDRU DLURL
		20/20	9	LUDLR DUDRL	URLUD ULDRL

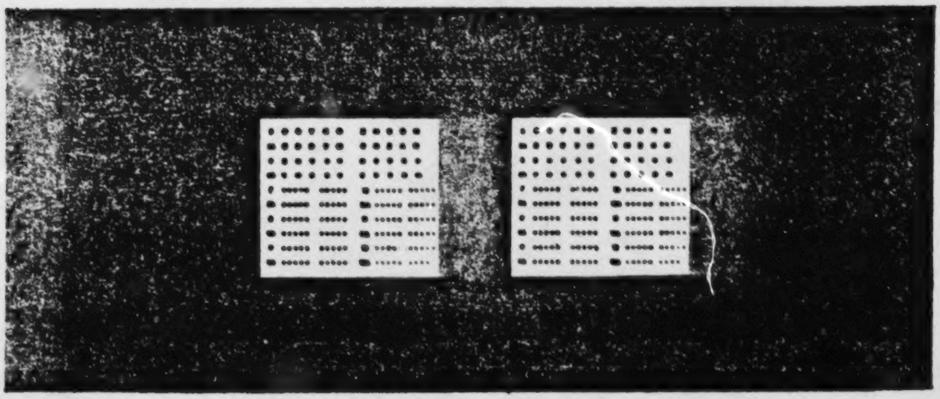
TABLE 3-2.



TEST NS 1 FAR BINOCULAR LETTER ACUITY (SMALL LETTERS)


K D S
Z S K C O
V R H D N
Z N S K H V D R C O
O Z O R H N S K D V
K D S
Z S K C O
V R H D N
Z N S K H V D R C O
O Z O R H N S K D V

TEST NS 2 FAR BINOCULAR LETTER ACUITY (LARGE LETTERS)



TEST NS 3 NEAR BINOCULAR LETTER ACUITY (SMALL LETTERS)

Figure 3-9. Binocular Acuity.

(1) If the examinee wears glasses, they must be removed before he enters the examining room. Each man will be tested without unnecessary delay after he has entered the room. To prevent personnel from memorizing the charts, only one examinee will be permitted to view the targets at a time. Personnel awaiting the test must be kept out of hearing.

(2) The examinee will be directed to the indicated 20-foot mark. The examiner will hold the occluder and cover the examinee's left eye, while instructing him to keep both eyes open without squinting. The occluder must not be permitted to touch any part of the eye to be shielded, but should be held in contact with the side of the nose.

(3) The examinee will be directed to begin with the first visible line and to read as many lines as possible. (The larger and less used lines should be kept covered.)

(4) The smallest line read on the chart from the 20-foot distance will be recorded as the vision for the right eye.

(5) The acuity for the left eye will then be tested, using a different chart and recording the same manner.

(6) Finally, the visual acuity for both eyes may be taken, if desired, with a third chart and recorded.

(7) A person who normally wears glasses all the time will be tested again with them in place. The same procedure will be followed as without glasses, for right eye, left eye, and both eyes, changing charts for each test.

(8) When there is suspicion that the examinee has memorized the charts, he will be directed to read the letters or targets in reverse order or will be shown a different chart. When suspicion still remains, further check for malingering will be done as outlined elsewhere in this Manual.

(9) The examinee is expected to read the letters promptly. No precise time limit should be applied but one or two seconds for each letter is ample time.

(10) When an examinee fails a letter or target, he should not be asked to read it again. If the examinee is a rapid reader and his mistakes are obviously careless ones, he should be cautioned to "slow down" and the test should be repeated on another chart.

(11) Some men give up easily. They may need encouragement to do their best. However no coaching will be given by the examiner.

b. Score Recording:

(1) Vision will be recorded in the form of a fraction, but in round numbers, that is 20/20, 20/40, not 20/20 +2, or 20/40 -3. The upper number is the distance in feet from the targets, and the lower number is the value of the smallest test chart line read correctly. Thus, a person reading the 30-foot test chart line at a distance of 20 feet is given a score of 20/30; 20/20 indicates that a person reads the test chart line marked 20 at a distance of 20 feet. Similarly, 20/200 means that a person can read only the test chart line marked 200 from a distance of 20 feet.

(2) When glasses are worn, the vision will be recorded both with and without glasses.

(3) Vision test charts vary from set to set in the number of letters per line. Therefore, in general, requirements establishing a specific visual acuity score will be so that the examinee must read correctly approximately 75 percent of the letters on a given line; e.g., if the 20/70 line has ten letters on the line, the examinee must read seven of these ten letters; if the 20/100 has four letters on the line, the examinee must read correctly three of the four letters to attain a score of 20/100.

c. Suggested Useful Phrases for the Examiner:

(1) "Please stand here (indicating the place). Hold your head still and straight. Keep both eyes open when I cover your left eye."

(2) "When I cover eye, don't close it, for that interferes with the test."

(3) "Start at the top and read as many lines as you can."

(4) "Don't squint. Don't screw up your eyelids or frown."

(5) "Look straight ahead."

(6) "Don't rub your eyes."

(7) "Read promptly—too much effort will tire your eyes and make it harder to read."

(8) "Don't hurry; get each one right that you can because you won't have another chance."

(9) "The next line may be hard but try it anyway."

(10) "If you're not quite sure, make a guess; play your hunches."

d. Precautions To Observe in Conducting Tests for Visual Acuity:

(1) An accurate measure of visual acuity may be difficult to obtain. The examiner must bear in mind that some men anxious to pass tests will resort to deception. Similarly, other men may take any means to fail a visual test when undesirable duties are in prospect. The examiner must be prepared to face either possibility and to recognize visual defects without cooperation. If the examiner is not a medical officer, questionable examinees should be referred to

SCORING KEY, VISION TEST APPARATUS, NEAR AND DISTANT VISION TESTING

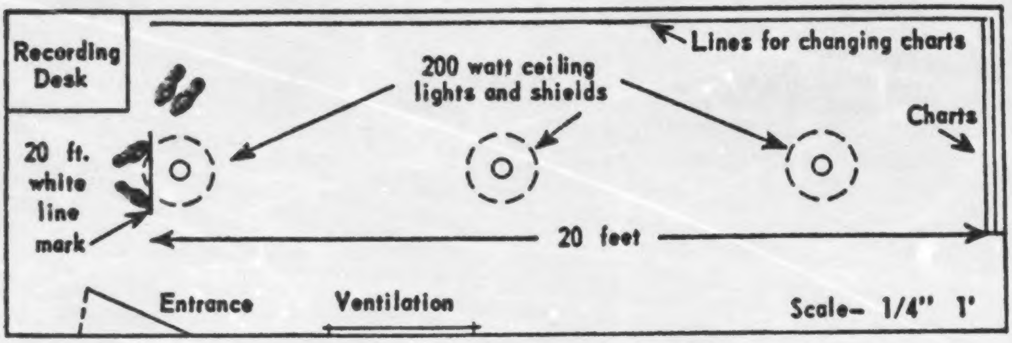
		NEAR TESTS		BINOCULAR ACUITY	
Score		Test 8—Small letters		Small letters	
		Left eye	Right eye	Test NS—3 near	Test NS—1 far
20/50	5	ZKCRV OHSDN	CVRZS DKHNO	OCVKR ZNSDH	OSDNH VKZCR
	5A	ORSNK VHDZC	OZRCV SKNDH	SDOVH CNZKR	SCVDK NZRHO
20/40	6	SDKVO ZRHNC	VZKCO HRSDN	ZHOCV NDRKS	RHZCD OSVKN
	6A	ZODVN HKSCR	NZCKO DSRHV	VNCSO KDZRH	OZNKR DVSCH
20/30	7	DHZRV SOKNC	HSZKN OVCDR	SDOVK HRNZC	SVNHO KCRDZ
	7A	NCKSR HZDVO	NRDVC ZKHOS	ZOHRC KDSNV	HNKZD VRCSO
20/25	8	DKOSN RVZCH	OVRHS CNDZK	DNHKO ZSRVC	RHSCK OZDVN
	8A	CKDSV OZNHR	VCHRD SKNZO	NSOZR VHKDC	CKDVO ZRNHS
20/20	9	KRZVD OSNCH	ZHCOR VDNSK	DSVKH ZNOCR	OZRVN HSCKD
	9A	VDOKH RZSCN	HVRSK ZODNC	NZOSR DVHCK	KDZRO VNHSC
20/17	10	OKSRN DHVCZ	RHCVN SDKZO	NZHKO RCVDS	DRHVN ZSKCO
	10A	HOVNC RZDSK	KRNHC DOSVZ	DNKOZ HSRVC	ZDSKC ORHNV
20/15	11	VRCHN OZKSD	CNZSR OHKDV	SNCZO RKVHD	OSKCV RZHDN
	11A	SVRNO CHZDK	DCVHK NOZSR	OCVNS DZKRH	CSHRV KNDZO
20/12	12	ROHKS VDNCZ	ODCNH VRSKZ	DHNVO SCZKR	SKHDN OCVRZ
	12A	KHRCV OSDNZ	RKCDO HVNZS	CNHRD OKSZV	KRSZC HNVDO
		Test 9—Large letters		Large letters	
		Left eye	Right eye	Test NS—4, near	Test NS—4, far
20/400	1	DSK	NVC	NVC	KDS
20/200	2	CRSZO	HNRCD	CZHSN	ZSKCO
	2	NDVHK	VOSZK	DKORV	VRHDN
20/100	3	OKZHS NCVRD	NDOCV RSZKH	KSDVO NHZCR	ZNSKH VDRCO
20/70	4	RCOVN DHKSZ	VRCNA OSDHK	VZOCS HRNKD	OZCRH NSKDV

INTERPRETATION OF PHORIA SCORES—FAR AND NEAR

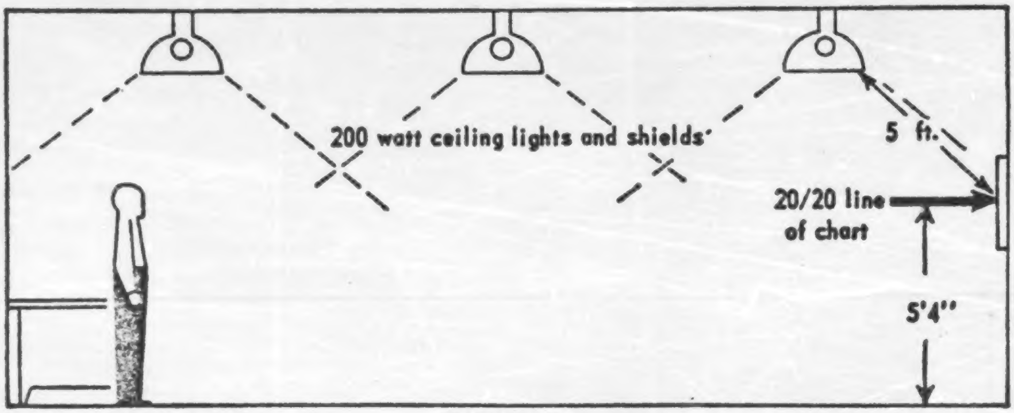
Tests 1 and 6

Score	1	2	3	4	5	6	7	8	9
Prism Diopters	2.0	1.5	1.0	0.5	0	0.5	1.0	1.5	2.0
	Left hyperphoria						Right hyperphoria		
Test 2	An instrument score of 11 indicates orthophoria. If instrument score is greater than 11, that amount greater indicates prism diopters of exophoria. If instrument score is less than 11, that amount less indicates prism diopters of esophoria.								
Test 7	An instrument score of 13 indicates orthophoria. If instrument score is greater than 13, that amount greater indicates prism diopters of exophoria. If the instrument score is less than 13, that amount less indicates prism diopters of espohoria.								

TABLE 3-3


Recording Desk
200 watt ceiling lights and shields
Lines for changing charts
Charts
20 ft. white line mark
20 feet
Entrance
Ventilation
Scale– 1/4" 1'

PLAN


200 watt ceiling lights and shields
5 ft.
20/20 line of chart
5'4"

ELEVATION

Figure 3-10. Room Plan - Essentials of Eye-Testing Room.

(a) If means are not available for measuring foot-lamberts of brightness, the room should be painted as directed in g(4) above, and lighted as described in (b) below. The brightness of the chart and walls will then approximate the requirements of 12 and 4 foot-lamberts respectively.

(b) A room is assumed about 24 feet long, 8 feet wide, and 10 feet high as shown in figure 3-10, "Room Plan." Such a room should be lighted by three 200-watt incandescent lamps placed at a height of about 9 feet from the floor. One lamp may be over or just behind the examinee's head. One lamp should be approximately in the middle of the room. One lamp should be exactly 5 feet diagonally from the 20/20 line of the chart at an angle of 45° (that is, 3 1/2 feet above the 20/20 line and 3 1/2 feet in front of it). All lamps must be shielded from the direct vision of the examinee by opal shades (not transparent) or metal reflectors; or a 4-inch strip of tin can be nailed to the ceiling in front of each lamp to accomplish the same purpose.

i. Test Charts. Chart set, Vision Acuity Testing, Distant Vision, Stock No. 6515-598-8078, will be used. To conserve the examiner's time and prevent immediate recognition of charts which may have been memorized, the large letters above 20/30 normally may be covered by white cardboard which can be swung aside or pulled up with a cord when it is necessary to use the larger test targets.

j. Occluder. A rigid occluder constructed of a material such as wood, opaque plastic or metal will be provided to shield the eye not being tested. An excellent design to discourage cheating is illustrated in figure 3-11.

one. Various tests for malingering are described under Visual Test for the Detection of Malingers. See paragraph 3-15.

(2) The examiner will watch the person being examined, not the chart which he is reading. The occluder must be held in such a manner that the examinee cannot see around it. The most frequently used method of increasing visual acuity is to squint with the eyelids. This will not be permitted. Some persons with astigmatism will be able to read the letters better by tilting the head to one side; the examinee should not be permitted to do this.

(3) Another well-known method used to pass a test for visual acuity is to obtain eye drops beforehand which contract the pupil. If the pupils are unusually small, the attention of a medical officer will be called to the fact. A thorough search must be made to assure that the individual is not wearing corneal or contact lenses.

(4) The occluder must not be pressed against the globe or lids, but rather it should be held against the side of the nose. The eye shielded by the occluder should be open in order to avoid pressure and to make squinting more difficult.

(5) Some men may appear to be malingering when they are not, and, on the other hand, the most innocent-appearing person may be the worst malinger. If malingering is suspected, the examinee should be referred to a medical officer for additional checks.

e. The Examiner:

(1) The examiner must be neat in uniform and professional in manner.

(2) Test results determine the duties to which personnel will be assigned; therefore, visual acuity must be determined with utmost care.

(3) The examiner must be unhurried and persevering to obtain accurate results. A patient, tolerant, and painstaking attitude on the part of the examiner will reassure examinees and increase the accuracy of the visual acuity test. Haste and irritation must be avoided.

(4) The examiner should undertake to memorize the test targets. If necessary, he may hold in his hand a small card on which the targets are reproduced, in order to verify the responses.

(5) The routine of examination must be followed carefully in the order described. The vision for each eye should be recorded as soon as it is determined so that errors and omissions will be avoided.

f. Retests:

(1) The effects of fatigue and alchohol may make a certain amount of retesting necessary. In questionable cases one retest will be given not sooner than the day after the initial test.

(2) Occasionally an excuse will be given for failure to pass the test because of temporary injury to the eyes. Examples are: That the candidate has gotten something in one or both eyes, that he has been exposed to welding flash, to bright sun, etc. Such cases will be referred to a medical officer.

g. Testing Room and Equipment:

(1) Size. The room used for testing visual acuity must provide a distance of 20 feet between the eyes of the person being examined and the targets.

(2) Equipment. A desk, stand, or high shelf will be placed so that the examiner can observe the candidate while recording the responses. The 20-foot mark must be carefully measured and clearly marked. (See accompanying room plan, figure 3-10.)

(3) Ventilation. Provision must be made for adequate ventilation of the testing rooms. This is of paramount importance.

(4) Color. Walls will be painted with flat, nonglossy, light gray paint of 40 percent reflectance or within a range of 35-50 percent reflectance. Walls must not be black. Ceilings will be painted white in order to approximate 75 percent of reflection. The trim, frame, or panel on which the charts are mounted should be painted a gray which is not darker than the walls. As a matter of appearance and upkeep, the general room trim, casings, etc., may be painted a slightly darker, semigloss gray. Windows and glass doors will be completely covered or curtained with material which is not in constrast with the color of the walls.

(5) Security. When the room is unused, there will be no access to the targets by persons who might profit by memorizing them.

h. Illumination:

(1) Room Brightness. The brightness of the walls of the testing room at head height will be not less than 3 foot-lamberts nor greater than the brightness of the test charts. Light from fixtures or openings must be shielded so that it does not shine in the candidate's eyes. There will be no glare sources or areas of high contrast in the field of view around the test charts. The quality of light is immaterial; incandescent or fluorescent is suitable.

(2) Target Brightness. The brightness of the charts will average 15 foot-lamberts and will be not less than 10 or more than 25 foot-lamberts. Under no circumstances will there be shadows or reflections visible on the charts.

(3) Lighting the Room:

3-7. Field of Vision:

a. The confrontation test is routinely employed. The test is based upon a comparison of the monocular fields of vision of examiner and examinee, which, assuming their facial conformations to be alike should be similar. The examiner will face the examinee at a distance of 2 feet. One or the other flexes his knees or rises on his toes so as to bring their heads to the same horizontal level. Each holds his head normally erect. The examinee closes his left eye with gentle pressure of the little finger and fixes his right eye upon the examiner's left eye. The latter closes his right eye and fixes his left upon the examinee's open eye. This fixation is continued throughout the test of the examinee's right eye. The examiner holds a plain white 3 mm. sphere on a wire handle overhead and in a plane midway between the two. He lowers the sphere keeping his hand out of the way, until it is seen by the examinee. Assuming similar brow conformation, the examiner and the examinee should see the sphere simultaneously. The superotemporal, superonasal, nasal, inferonasal, and inferior limits of the field of vision are similarly compared. To estimate the examinee's temporal and inferotemporal limits of vision, the sphere is held behind the plane of the examinee's eye and brought forward until visible; in these meridians the visual field normally extends to 90° or more. A similar technique is used to test the left eye.

b. If on the confrontation test the field of vision appears to be constricted to a degree not attributable to prominent nose or brow, or if for any other reason the examiner suspects a visual field defect a more exact perimetric study is made, employing the perimeter and tangent screen.

c. The average normal field for form is approximately as follows: Temporally 90° or more, supertemporally 62°, superiorly 52°, superonasally 55°, nasally 60°, inferonasally 55°, inferiorily 70°, an inferotemporally 85°.

3-8. Color Vision:

a. General Color vision does not change except in case of eye or central-nervous-system disease. If a satisfactory test is on record and available, the test need not be repeated on annual or other routine examinations.

b. Screening Test. The standard screening test consists of one demonstration plate and 14 test plates in a ring binder. The standard item, Plate Set, Pseudoisochromatic, 15 Plates, Stock No. 6515-299-8186 will be used.

(1) Light source. The test shall be administered under the easel lamp listed as Light, Color Perception Testing, Stock No. 6515-345-6625.

(2) Procedure:

(a) The easel lamp should be placed on a table or shelf so that the applicant's line of sight is at right angles to the plates and so that his eyes are at a distance of approximately 30 inches (plates just out of arm's reach). The applicant should not face an open window or other strong light. Nearby incandescent lights should be shielded so that they do not illuminate the plates. Nearby window shades should be drawn.

(b) The examiner shall instruct the applicant to "please read the numbers." The examiner shall not give other instructions and shall not ask other questions. The applicant is not allowed to trace the patterns or touch the test plates.

(c) The demonstration plate must be shown first. All of the remaining 14 plates are then shown. About 2 seconds should be allowed for response to each plate. If the applicant hesitates he should be asked again to "read the number"; if he fails to respond, the examiner turns to the next plate without comment.

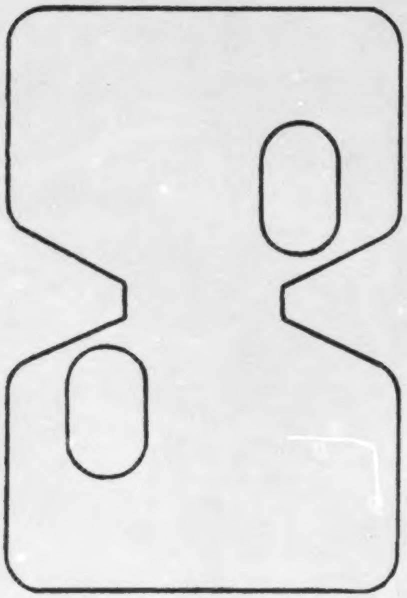
(d) With the exception of the demonstration plate which is always first, the examiner must change the order of the plates frequently. The change should be made at least weekly and oftener if there is suspicion that the numbers have been learned in serial order by applicants.

(3) Scoring:

(a) If 10 or more responses to the 14 test plates are correct, the examinee will be considered as having normal color perception. The entry, Passes—VTS-CV, will be made in item 64, SF 88. If 5 or more incorrect responses are given, including failures to make responses, the examinee will be considered as having deficient color perception. The entry, Fails—VTS-CV, will be made in item 64, SF 88, with the number of incorrect responses.

(b) The demonstration plate is not considered in scoring. In plates with two-digit numbers incorrect responses to either is a failure for the plate.

c. Quantitative Test. The quantitative test is the Vision Test Apparatus, Color Threshold Tester, Stock No. 6515-388-3700. The color threshold tester uses eight colors presented in a specified order at eight different levels of intensity, a total of 64 test lights. The upper dial at the rear of the instrument controls the intensity of the test color. When in position 1, the intensity is at the lowest level; when in position 8, at the highest level. The lower dial con-



SUGGESTED DESIGN FOR OCCLUDER
(To fashion occluder, multiply each
of the above dimensions by 2.)

Figure 3-11.

3-6. Near Vision:

a. General. Near visual acuity is determined for each eye separately. For Flying Class I and IA examinations, glasses will not be worn. For all other examinations, near vision will be recorded, both with and without correcting lenses, if glasses are worn or required. Individuals over 40 years of age may wear presbyopic correction up to +2.50 sphere. Correction worn will be noted on report of examination.

b. Test Cards. Near vision testing will be done using Chart Set, Vision Acuity Testing, Near Vision, Stock No. 6515-598-8077, at a distance of approximately fourteen inches. The examinee will be instructed to read the smallest print possible.

c. Recording. Near visual acuity will be recorded using the system with the numeral 20 as the numerator. Visual equivalents for interpretation of various common near vision test cards are listed in table 3-4.

Table 3-4

TABLE 3-4--Interpretation of Test Cards

Snellen English linear	Standard test chart	Snellen metric	Jaeger
20/20	14/14	0.50M	J-1
20/25	14/17.5	.62	J-2
20/30	14/21	.75	J-4
20/40	14/28	1.00	J-6
20/50	14/35	1.25	J-8
20/70	14/49	1.75	J-12
20/100	14/70	2.25	J-14
20/200	14/140	....	....

TABLE 3-5. Typical Records on Color Threshold Tester.

TEST 1									TEST 2								
INTENSITY LEVEL	COLORS								INTENSITY LEVEL	COLORS							
	1r	2a	3g	4b	5y	6r	7w	8g		1r	2a	3g	4b	5y	6r	7w	8g
1	-	r	b	-	r	r	·r	w	1	b	r	b	g	a	g	g	b
2	y	y	w	w	y	r	w	w	2	b	a	w	b	y	g	a	w
3	y	y	g	g	y	r	y	g	3	g	y	w	g	r	r	w	a
4	r	y	g	g	y	r	y	g	4	g	r	w	b	y	r	r	w
5	r	y	g	g	y	r	w	g	5	y	y	g	b	y	r	a	w
6	r	o	g	g	y	r	y	g	6	r	r	w	b	r	r	w	y
7	r	o	g	b	o	r	w	g	7	a	r	b	b	r	r	w	w
8	r	o	g	b	o	r	w	g	8	a	r	w	b	r	r	w	w
Score 52	5	7	6	6	7	8	7	6	Score 17	0	0	0	8	0	6	3	0
Answers counted correct	r	o a y	g b	b g	y w a o	r	w y	g b									

r=red y=yellow o=orange a=amber g=green b=blue w=white

(5) The Landolt ring is presented first at 5 feet in any of its four settings in random order. The subject must get 4 out of 4 or 8 out of 10 correct. If he does well at 5 feet, the examiner will move to 6 feet and on out until he fails to get 8 out of 10 correct. Persons who receive an unsatisfactory score will be carefully retested, the best score obtained being taken as the test score. Scoring will be entered on the SF 88 as Superior (Sup.), Satisfactory (Sat.), and Unsatisfactory (Unsat.).

(6) Score Classification

10 or more feet—Superior.

5 to 9 feet—Satisfactory.

Less than 5 feet—Unsatisfactory.

3-10. Depth Perception:

a General. Testing of depth perception using the VTA-ND as described in Chapter 2 is desirable as a screening test and will be considered the standard test. However, when the machine vision tester is not available, or if the examinee fails the standard test, the Verhoeff depth perception apparatus or the Howard-Dolman apparatus is acceptable. Applicant for pilot training will not wear corrective lenses while these tests are being performed.

b. Depth Perception Apparatus, Portable, Verhoeff:

(1) This is a binocular test. The apparatus provides the shifting, with each exposure, the relative position of three vertical rods. One rod is always nearer to, or farther away from the examinee, than the other two. One or two positions are shown at close range to the examinee to demonstrate clearly that one rod is always closer or farther than the other two; with this further explanation that the size of the rods is not a clue to the relative distances. Eight different rod relations are possible by showing four and then reversing the instrument for four more. All eight positions will be used in this examination.

(2) The device should be kept centered on a frontal plane normal to the subject's binocular vision midline. To avoid helpful extraneous cues the exam-

trols the color of the test field.

(1) Procedure:

(a) The test is given in a dark room. The examinee is seated at a distance of 10 feet from the front surface of the instrument. He is told that the center light is the test light; the smaller lights on either side, guide lights to help him locate the test light. He is instructed to look midway between the two guide lights and is told that red, green, blue, white, yellow, and amber or orange lights will be shown. Before starting the actual test, a demonstration is given. The series of eight colors is shown at the highest intensity starting with color No. 8. Each is shown for about 5 seconds and is named by the operator. When the demonstration is completed, the person again is reminded to look midway between the two guide lights and to use only the names red, green, blue, white, yellow, and amber or orange. If he sees no light at all, he reports "Nothing." If he sees the test light but is not sure what name to give the color, he must guess.

(b) In the actual test the operator will present the 64 test lights as follows: He sets the intensity dial at No. 1 (lowest level) and shows the eight colors in order from No. 1 to No. 8. He then shifts the intensity disk to No. 2 and shows the eight colors in order from No. 8 to No. 1, then shifts the intensity disk to No. 3 and shows the colors from No. 1 to No. 8, etc. He writes the answers in a special blank, r for red, etc. The examinee is not allowed to change his answer after seeing the next test light.

(c) The answers counted correct for each of the eight colors are specified at the bottom of the record blanks. Thus, red is the only correct answer for the test colors No. 1 and No. 6. Color No. 2 may be called orange, yellow, or amber. Colors Nos. 3, 4, and 8 may be called either blue or green. Color No. 7 may be called white or yellow. A part score for each of the eight test colors is obtained by counting the correct responses, starting at the highest intensity level (No. 8) and counting to lower intensities until an error is made. Correct responses at still lower levels are not counted. Thus, if test color No. 1 is called red at levels 8 and 7 and amber at level 6, a score of 2 is entered for this test light. The method of obtaining the part scores is further illustrated under (2) below. The total score is the sum of the eight part scores.

(2) Typical Records on Color Threshold Tester. (See table 3-5.)

d. Interpretation of Results. Four degrees of color discrimination are distinguished by these tests. They are defined as follows:

(1) Normal Color Vision. Four or less errors in reading the 14 testing plates. (The quantitative test is not given if the screening test shows normal color vision.)

(2) Deficient Red-Green Color Perception, grade 1. Five or more errors on screening test; score 50 or better on quantitative test.

(3) Deficient Red-Green Color Perception, Grade 2. Five or more errors on screening test; score 49-35 on quantitative test.

(4) Deficient Red-Green Color Perception, grade 3 (complete red-green color deficiency). Five or more errors on screening test; score 34 or less on quantitative test.

e. Deficient Color Vision. When deficient color vision had been established in an individual, the screening test need not be repeated in subsequent examinations since congenital color blindness is unchanged throughout life. Acquired defects in color discrimination will be detected by tests of visual acuity or visual fields. The degree of deficiency in color perception, when congenital, is likewise unchanged throughout life. Minor fluctuations in the score on the quantitative test do, however, occur because of chance factors. Therefore, when the score is within three points of the critical scores for grades 1, 2, and 3, the test should be repeated, and the classification of degree of defect based on the average (not the highest) score of two or more independent tests. Otherwise, repetition of the color vision test at regular intervals in unnecessary.

3-9. Night Vision:

a. General. A careful history of night-vision difficulty will be taken on all original examinations for flying. Night-vision testing will not be done unless there is reason to suspect a night-vision deficiency, because of familial or personal history, fundus changes, behavior in dim light, etc. The standard night-vision tester is Adaptometer, Radioactive Plaque, Night Vision, Stock No. 6515-382-1000.

b. Testing Technique:

(1) The tester will be opened only in the dark. If exposed to light it may not be used for 24 hours.

(2) A good dark room must be used. No light leaks should be visible after 30 minutes' adaptation.

(3) The test is a Landolt ring on a radium plaque presented to the examinee at various distances.

(4) Unless great care is taken in performing the test, the results may not reflect the examinee's true night-vision efficiency. The operator will explain to the subject the necessity for looking slightly above, below, to the left or right of the target until he finds the direction of fixation at which he can best see it.

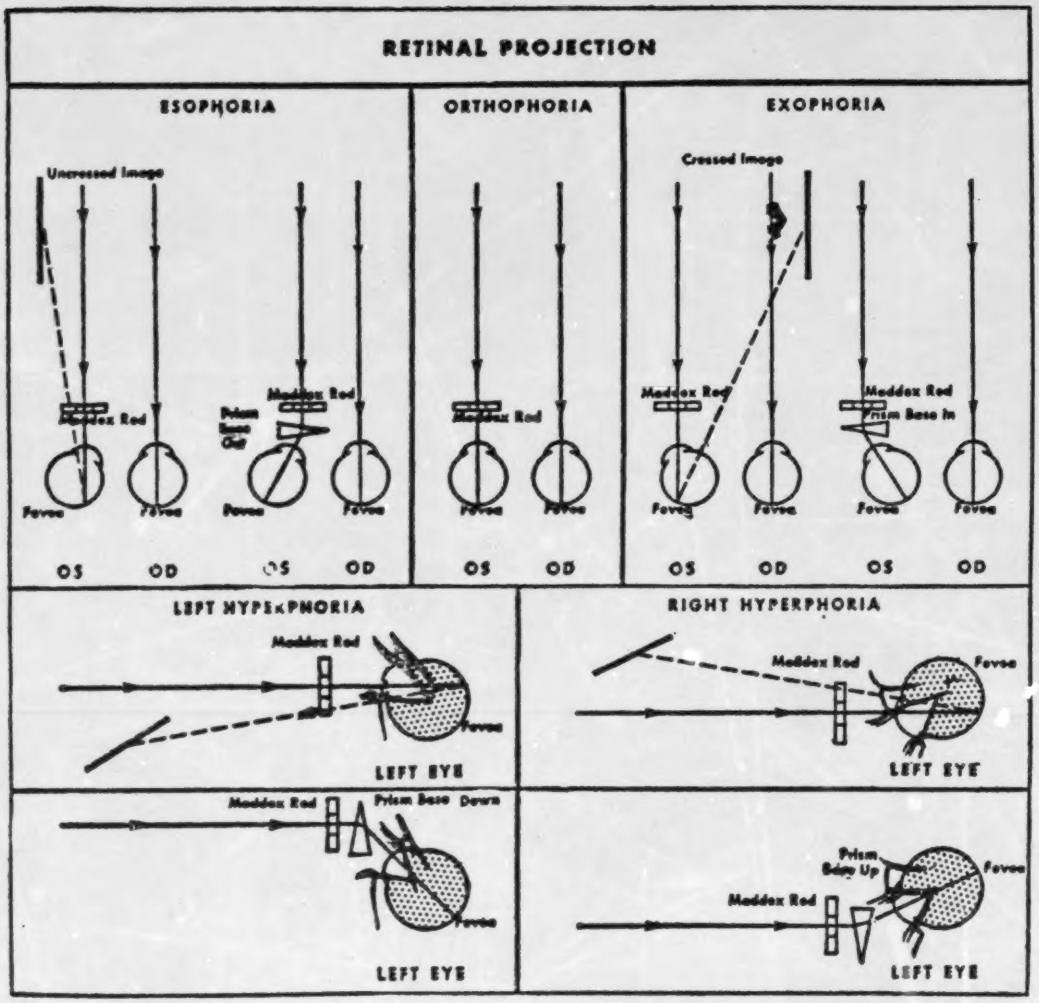

RETINAL PROJECTION
ESOPHORIA
Uncrossed Image
Maddox Rod
Fovea
Fovea
Maddox Rod
Prism Base Out
Fovea
Fovea
OS
OD
OS
OD
ORTHOPHORIA
Maddox Rod
Fovea
Fovea
OS
OD
EXOPHORIA
Crossed Image
Maddox Rod
Fovea
Fovea
Maddox Rod
Prism Base In
Fovea
Fovea
OS
OD
OS
OD
LEFT HYPERPHORIA
Maddox Rod
Fovea
LEFT EYE
Maddox Rod
Prism Base Down
Fovea
LEFT EYE
RIGHT HYPERPHORIA
Maddox Rod
Fovea
LEFT EYE
Prism Base Up
Fovea
Maddox Rod
LEFT EYE

Figure 3-12. Retinal Projection.

(2) A comfortable testing chair located at one end of the room.

(3) A muscle light (spot of light 1 cm. in diameter, placed at a distance of 20 feet from the eyes of the seated examinee and facing him).

(4) An ophthalmoscope with a removable, May-type head.

(5) One of the following:

(a) A binocular phorometer or phoropter (refractor) with Risley rotary prisms and Maddox rods, or

(b) A monocular, portable phorometer with a Risley rotary prism and white Maddox rod attached, or

(c) A trial frame with a while Maddox rod and graduated and accurately calibrated prisms, either loose or arranged vertically in a prism bar.

(6) Some method of measuring exactly 13 inches from the front of the phorometer. A cord tied to the phorometer and either looped or knotted at the proper length is satisfactory. Some phorometers have a metal rod to which a small light may be attached in order to measure accurately heterophoria at 13 inches.

iner must hold the device steady, and not rotate it on its vertical axis. Moreover the examinee must not be permitted to move his head. The target window should not be exposed while the device is being placed in position or while the sets are changed. A convenient method of manipulation is to grasp the device over the target window with the left hand, place the desired set into position with the right hand, then grasp the device below with the right hand and expose the target window by moving the left hand up or down. Thus, while the target window is exposed, the device is supported by both hands of the examiner.

(3) The examinee should answer for each of the eight presentations correctly. If an error is made on the first run, two more runs will be made and the examinee must report eight out of eight correctly on both trails. If this is not done, the examinee will be failed. The score will be reported as "Passes" or "Fails."

(4) Test Distance: one meter between examiner and examinee.

c. Howard-Dolman. The test will be done at a 20-foot distance. At least five readings should be made. If these are abnormal or widely variable, 10 readings will be made. If the examinee wears correcting lenses while flying, the examination will be repeated with the examinee wearing his proper correction for distance. The average obtained with and the average obtained without correction will be recorded. The examiner will explain the working of the apparatus to the examinee. The movable rod is then placed well away from the fixed rod while they are screened by the examiner from the examinee. The examiner steps aside, passes the cords to the examinee, and directs him to adjust the rods to an equidistant position. The following precautions should be taken:

(1) The examinee will not be permitted to move his head while adjusting the rod.

(2) The cord should have no means of position reference, knots, frayed areas, etc.

(3) The examinee will not be permitted to draw the movable rod from end to end of the box.

(4) The cord should be removed from the examinee's hands and the rods screened from his view while readjustment is being made.

3-11. Heterophoria and Ocular Motility:

a. General. Heterophoria is a condition in which the eyes have a constant tendency to deviate but are prevented from so doing by fusion. It will be determined in every class I or class II medical examination for flying and when indicated clinically in a standard medical examination. When a person looks at an object, an image of that object is formed separately in both the right and the left eyes. These separate images are sent to the brain where they are associated and interpreted as a single image: this process is knows as fusion. Fusion is responsible for the two eyes' working together in harmony and when anything prevents this, fusion is disrupted and one eye deviates. Since heterophoria is only a tendency of the eyes to deviate, no actual deviation is apparent when the eyes are being used together under ordinary conditions. The deviation becomes visible only when fusion control is weakened or abolished. When deviation occurs, its exact amount can be estimated with some accuracy by neutralizing the deviation with prisms of varying strength. If the deviating eye turns in (toward its fellow), the deviation is knows as esophoria; if it turns out (away from its fellow), the deviation is known as exophoria; if the deviating eye turns up, the deviation is called hyperphoria (figure 3-12).

(1) Breaking up Fusion. For heterophoria measurement, fusion can be disrupted by placing a Maddox rod in front of one eye. The image of a spot of light, when viewed through a Maddox rod, is converted into a line of light. When the two eyes see unlike images of the same object (one eye sees a spot of light while the other eye, the one behind the Maddox rod, sees a line of light), this disrupts fusion and tends to prevent the two eyes from working together. Thus, when heterophoria is present, one eye (the eye behind the Maddox rod) will deviate, while its fellow eye continues to look at or fixate the spot of light.

(2) Standardization of the Test. The measurement of heterophoria is one of the most difficult problems that the inexperienced examiner can meet. There are many factors which influence the test and only a few of these are actually known. For example, it is just as important to have the examinee seated comfortably during the test so that his neck muscles are not strained as it is to have the testing equipment in good condition. Strained positions of the head and neck have a definite effect upon the measurement of heterophoria. Unless the test is performed in exactly the same way at every testing station, an examinee may pass the test at one station on one day and fail it on the next day at another station. Therefore, a uniformly standardized testing technique must be used at every station.

b. Necessary Equipment:

(1) A testing room long enough to provide a distance of 20 feet between the muscle light and the eyes of the seated examinee.

rods which make up the multiple Maddox rod should be in the horizontal meridian. With the rod in this position, when the examinee looks at the muscle light, he sees a vertical white line with his right eye (which has the Maddox rod in front of it) and a spot of light with his left eye. He is thus seeing unlike images of the same object.

(b) The examinee should now be specifically questioned whether he sees both the vertical white line of light and a white spot of light. If he does, the testing may proceed. If he does not see both the line and light at the same time, one of several things may have happened:

1. The phorometer frames may not be exactly centered before each eye.

2. Although properly centered, the phorometer may not be aimed exactly at the light.

3. The examinee may have closed one eye. Both eyes must be kept open at all times during the test.

4. The examinee may be unconsciously suppressing vision in one eye. (See (4) below.)

5. Visual acuity may be poor in one eye.

6. One eye may be turned far in or far out; if one is deviating a great deal ("cross-eyed" or "walleyed"), this fact should have been noted on external examination. The presence of a manifest deviation is known as heterotropia, and no heterophoria measurement is accurate or is usually even possible in such cases.

(4) Suppression:

(a) Double vision is usually avoided by the natural impulse to line up the two eyes so that they work together. In the presence of heterophoria, the examinee fuses the two images into one but to do this requires effort (whether he is aware of it or not). If the required effort is too great, one of the two images may be ignored by the brain. This is known as suppression. In the case of the Maddox rod test, it is somewhat annoying to perceive a spot of light with one eye, yet see a line of light with the other. The image of the line is often suppressed (ignored) by the brain, which means that it seems to fade in brightness and may disappear entirely.

(b) If the examinee sees only the line, or only the light, or the line and then the light alternately, it may be assumed that he is suppressing, provided that:

1. The phorometer is properly adjusted.

2. Visual acuity is normal or anywhere near equal in the two eyes.

3. No gross deviation of the eyes is apparent on external examination (inspection).

(c) If the examinee sees only the spot of light (using his left eye), the left eyepiece of the phorometer should be covered with an occluder until the light is seen by the right eye. If the cover is then removed, the line and light will usually be seen simultaneously. Likewise, if only the line is seen (using the right eye, which has the Maddox rod in front of it), the occluder should be placed over the right eyepiece of the phorometer until the spot of the light is seen by the left eye. If may then be removed.

(5) The Risley Rotary Prism. Instructions to the examinee:

(a) Having assured himself that the examinee sees both the line of light (seen through the Maddox rod) and the spot of light, the examiner is ready to begin the test. Since the examiner adjusts the Risley prism, the examinee need only be instructed to tell the examiner when the line of light runs right through or bisects the spot of light. The instructions would therefore be something like this: "I AM GOING TO MOVE THE LINE. I WANT TO ADJUST IT SO THAT IT RUNS RIGHT THROUGH THE CENTER OF THE SPOT OF LIGHT." The examiner then slowly turns the knob controlling the Risley prism in one direction or the other, meanwhile asking, "IS THE LINE MOVING TOWARD THE LIGHT OR AWAY FROM IT?" If the examinee replies that the line is moving away from the light, the examiner immediately begins turning the Risley prism control knob in the opposite direction, meanwhile asking, "NOW IS THE LINE GOING TOWARD THE LIGHT?" When the examinee indicates that the line is moving toward the light, the examiner continues to turn slowly, saying, "WHEN THE LINE RUNS THROUGH THE EXACT CENTER OF THE LIGHT, TELL ME TO STOP." When the examinee states that the line is running through the center of the light, the scale reading is recorded.

(b) The examinee may often state in one breath that the line is running through the light and in the next breath state that this is no longer the case. The examiner should reassure him by telling him that it often happens and continue adjusting the prism until the line stops moving and an accurate reading can be made.

(6) The Maddox-rod Test at 20 feet:

(a) Lateral Heterophoria:

1. The examiner should always begin the test with the Risley prism set off zero in one direction or the other, so that some adjustment will have to be made in every case. When the reading is completed,

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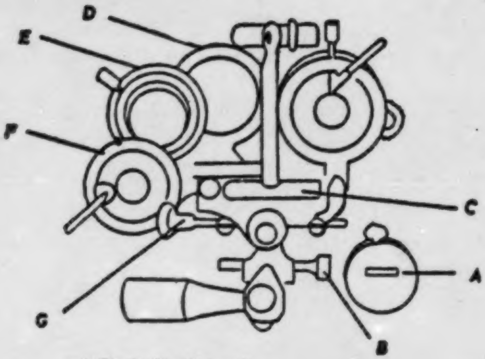

A Single Maddox rod
B Leveling device
C Bubble
D Triple cell (one rotary) for trial lenses
E Risley rotary prism
F Multiple Maddox rod
G Adjustment for interpupillary distance

Figure 3-13. Phorometer Trial Frame and Single Maddox Rod.

c. Testing With the Binocular Phorometer (figure 3-13):

(1) The examinee should be comfortably seated in a chair. A straight-backed chair with arms is preferable to a stool. If there is a head rest on the chair, it should be accurately and comfortably adjusted.

(2) The phorometer should be carefully adjusted to the examinee, not the examinee to the phorometer. He should never be told to "come forward a little," to "stretch your neck a bit," or "move your head sideways (to right or left) a little bit." The examiner must make these adjustments himself with the various controls on the phorometer; that is why they are there. Adjusting the phorometer means several things. It means:

(a) The entire length of the brow-piece touches the examinee's forehead, exerting gentle but firm pressure.

(b) The bubble in the spirit level is accurately centered between the two markers.

(c) The interpupillary distance reading is set on the scale and the phorometer is high enough so that each of the examinee's pupils is exactly centered behind its respective frame.

(d) The examinee is seated and the phorometer placed so that both are exactly and directly facing the muscle light across the room.

(e) If the examinee wears glasses all the time, any test of heterophoria should be made with the equivalent of his lenses inserted in the phorometer. Candidates for flying training will not be allowed to wear glasses during examination of their phorias.

(3) The Maddox Rod:

(a) The examinee's attention is directed to the muscle light. To insure his seeing it, the examiner should flash it on and off a time or two by means of a remote-control switch located conveniently near at hand, if this is available. There must be no other sources of light except the muscle light visible to the examinee. There may be other lights in the room as long as the examinee cannot see them. All reflecting surfaces should also be removed from the examinee's range of vision. If this is not done, the overhead light which the examinee cannot see directly may nevertheless be reflected into his eyes from any shiny metal or glass objects in the room. If this reflection occurs, more than a single line may be seen through the Maddox rod and will prove to be a disturbing factor if not a source of actual error in the test. When the examinee has definitely located the muscle light, a white multiple Maddox rod attached to the phorometer should be rotated into position. This means rotating it on its hinge as far as it will go. The rod should be placed before the right eye. The axes of the small

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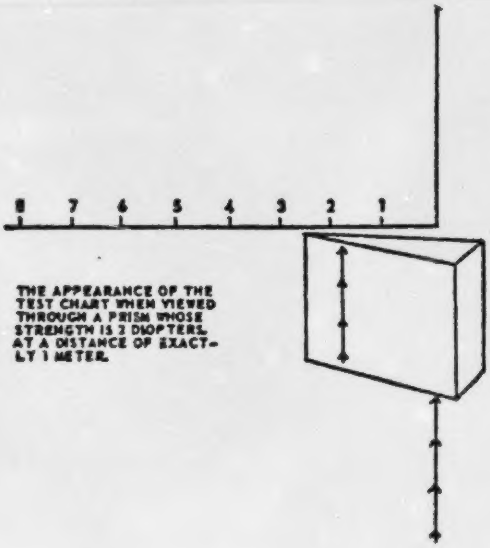
(1) The line of light may be indistinct rather than sharp.

(2) A prism effect may appear which deflects the line of light from its true position. A Maddox rod which is found to have either of these defects should be discarded. If the line of light formed by the rod is sharp and clear, any prism can be readily detected by holding the rod before one eye so that a horizontal line of light is seen with that eye while the other eye sees a spot of light. The position of the line in relation to the light is observed. The rod is then rotated through a full 180° and the line and light relationship observed again. If no prism is present, the relationship should be identical in the two observation positions described.

g. Checking Prisms:

(1) If a phorometer with a Risley rotary prism attached is not available for heterophoria testing, it will be necessary to use loose prisms. These may be available either in a trial case or in a special box (prism set). The strength of each prism should be etched upon the prism itself in units of prism diopters, this prismatic unit being the one used throughout the Armed Forces. Unfortunately, not all prisms are marked in these units, some are not marked at all, and still others are marked incorrectly. Therefore, the strength of each prism will be checked before it is used in the measurement of heterophoria. This can be very easily and very simply done.

(2) A diagram (figure 3-14) is made on a white sheet of paper 8 1/2 by 11 inches in size. A heavy black line is drawn about 1 inch from and parallel to one edge. A second, lighter line is drawn perpendicular to the heavy line in such a way that the heavy line is bisected. Using a meter stick, units of 1 cm. are laid off on the second line. These units should be numbered consecutively, the mark nearest the heavy line being numbered "1." This chart or diagram should then be tacked in place on the wall in such a manner that the heavy black line is vertical while the line with the centimeter markings runs to the left of the heavy line. A series of arrowheads added to the heavy line below the point of the intersection will facilitate the checking.



THE APPEARANCE OF THE TEST CHART WHEN VIEWED THROUGH A PRISM WHOSE STRENGTH IS 2 DIOPTERS. AT A DISTANCE OF EXACTLY 1 METER.

Figure 3-14. Checking Prism Strength.

(3) The prism to be checked is held at a distance of exactly 1 meter from the diagram on the wall and in a plane parallel to the plane of the wall. The base of the prism should be held in the vertical, toward the right, and parallel to the heavy black line on the chart. The examiner should then place his eye at a distance of about 4 inches from the prism in such a position that he can view the heavy black line

if the prism marker is on the side of the line toward the examinee's nose, exophoria is present; if on the side toward the examinee's temple, esophoria is present.

2. If any doubt exists in the mind of the examiner about the results of the test, the examinee should be referred to the medical officer in charge.

(b) Vertical Heterophoria. With the Maddox rod before the right eye, the rod should be adjusted so that the axes of its component glass rods are vertical. The eye behind the rod now will see the spot of light as a horizontal line. The Risley prism is turned with the zero point on the 0-180° axis. The examiner will set the Risley prism off zero in one direction or the other (approximately 3 to 4 prism diopters). The examinee is told that he should see a horizontal line and a spot of light.

(c) The examiner grasps the controlling knob of the Risley prism and turns it slowly until the examinee states that the line bisects the spot of light. If the examinee reports that he also sees another spot of light he is told to ignore the faint spot and to watch the line until it bisects the bright spot. The examiner then reads the scale of prism diopters of hyperphoria.

1. Only hyperphoria is recorded. Any phoria is the relationship between the position of the two eyes. Vertical phoria is always recorded as hyperphoria of the higher eye.

2. If there is any doubt about the measurement in the mind of the examiner, the test may be repeated with the test equipment in front of the left eye. A differnce of more than 0.5 prism diopters between the measurements should be cause for a recheck of the hyperphoria measurements for each eye. In this case the test should begin with the index set at 2.0 RH (right hyperphoria), the examiner moving the line in the opposite direction as described above until the line bisects the spot of light. The averages for the settings "from below" and "from above" when the Maddox rod is before the right and the left eyes should be compared. If the difference is greater than 1.0 prism diopter there is, in all probability, a slight paralysis of one or more of the extraocular muscles and a red-lens test with the charting of the diplopia fields is indicated.

(7) The Maddox-rod Test at 13 Inches:

(a) The muscle light is turned off and the test will then be performed at 13 inches, using an ophthalmoscope with its head removed as the muscle light. The light should be held exactly in the midline and 6 inches below the level of the examinee's eyes; thus the eyes are in the reading position. The examiner may have to lower the phorometer slightly and adjust the interpupillary distance in order to keep the eyes accurately centered. The light will be held at a distance of exactly 13 inches from the phorometer. If a string is tied to the center bar of the phorometer and looped at 13 inches, the ophthalmoscope neck slipped into the loop and the cord drawn taut, the light will be exactly 13 inches from the phorometer each time the test is performed.

(b) The technique of testing lateral and vertical heterophoria at 13 inches is exactly the same as that used at 20 feet. Occasionally the examinee may complain that he sees more than one line at the 13-inch distance. If the source of this annoying reflex cannot be found, he should be instructed to pay attention only to the brighter line while it is adjusted so that it runs through or bisects the spot of light.

d. Testing with the monocular portable phorometer. The principle of measuring heterophoria with a Maddox rod and prisms may be applied in several different ways. Because the equipment available for the test varies from one station to the next, two additional testing methods will be described. At some installations a binocular phorometer may not be available but instead, only the monocular, portable type. This consists of a stick with an eyepiece mounted at one end in a fixed position. Rotating on an axle attached to the eyepiece are a Risley rotary prism and a white Maddox rod. The instrument is held by the examinee in his left hand before the left eye and the test is carried out exactly as has been previously described. The examiner will make certain that the instrument is held in the proper position at all times during the test.

e. Testing With a Trial Frame and Loose Prisms. If no phorometer is available, a trial frame should be carefully adjusted before the examinee's eyes. A white Maddox rod from the trial case is placed in the cell before the right eye; its component rods should be placed with their axes horizontal if lateral heterophoria is to be tested first. When the examinee has located both the line and the light, the examiner should select a weak prism and hold it before the Maddox rod with its base either in or out. Care must be taken to keep the base of the prism exactly vertical if lateral heterophoria is being tested or exactly horizontal if vertical herterophoria is being tested. Several prisms should be tried (both base in and base out) until one is found which causes the line to bisect the spot of light. The rest of the procedure will be carried out exactly as had been described previously.

f. Checking the Maddox Rod. Two defects may occasionally be found in a Maddox rod:

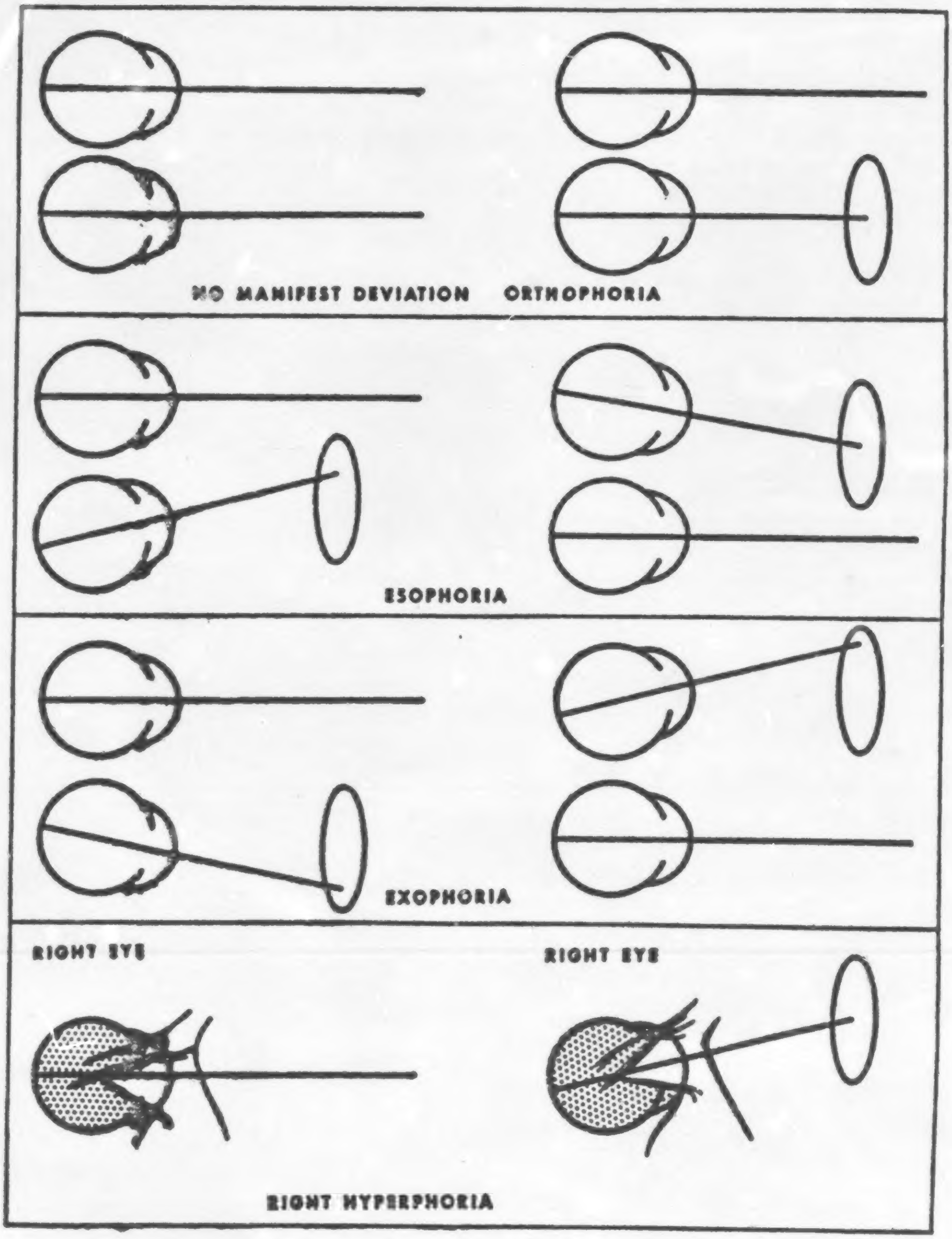

NO MANIFEST DEVIATION
ORTHOPHORIA
ESOPHORIA
EXOPHORIA
RIGHT EYE
RIGHT EYE
RIGHT HYPERPHORIA

Figure 3-15. Heterophoria as shown by Cover Test.

through it. As shown in figure 3-14, the top edge of the prism should be held so that it is just below but almost coincides with the lighter marked line on a diagram. The position of the heavy black line above the intersection of the two lines should be such that it strikes the prism's upper edge at about its center. If the left eye is now closed and one looks through the prism, held in the position described, the heavy black line will appear to break at the prism edge and continue its downward course in a position to the left of its original one. The centimeter marking to which the arrowheads on the displaced portion of the heavy line point is a measurement of the strength of the prism in diopters. If the arrowheads point to a spot between two markings, the appropriate fraction can be easily estimated. If the test is carried out as described and the displaced portion of the heavy line intersects the marked line at 3, for example, the prism being tested has a strength of 3 diopters. If the displaced portion intersects the marked line at 5, it is a 5-diopter prism, etc.

h. Near Point of Convergence (PC):

(1) Near point of convergence will be determined for all personnel being examined for flying qualification in classes I and II. Candidates for flying training will not be allowed to wear corrective lenses while being tested for near point of convergence. With the zero mark of the Prince rule placed approximately 15 mm. from the anterior corneal surface, the point of convergence is that point on the rule which marks the greatest convergence of the eyes. It is recorded in millimeters. If correcting lenses are necessary to meet the distant or near vision acuity standards, such correction will be worn during this examination.

(2) Prolonged repetition usually tires the extraocular muscles and gives erroneous measurements. Before an examinee is disqualified for insufficient power of convergence, he will be examined on 2 successive days and the nearest point of convergence recorded.

i. Cover Test:

(1) General. The cover test will be performed on all classes of flying physical examinations, for commission, and Air Force Academy. The test will be performed at 20 feet and at 13 inches.

(2)Testing Procedures. The cover test, as described here, is designed to enable the examiner to diagnose heterotropia or heterophoria. It is done in two phases: The "alternate cover" which elicit movement of the eyes, and the "cover-uncover" which allows the examiner to determine whether this movement is due to heterotropia or heterophoria. The first phase is done as follows. The examinee is requested to fix his gaze on the test object. The occluder is placed before each eye alternately, moving quickly from one eye to the other at slightly irregular intervals for a period of about 15 seconds. During this time the examinee is not permitted to see binocularly. The eye movement seen during this phase may be either a heterophoria or a heterotropia and may be measured by introducing appropriate prisms to eliminate the eye movement. The second phase, "cover-uncover" test, is begun by first removing the occluder and giving the patient an opportunity to fix binocularly for a few seconds. The occluder is then placed before one eye, removal for a few seconds, and placed before the other eye. The examiner focuses his attention on the eye which is not being covered, if it moves to fixate at the moment that the opposite eye is covered, the observed eye was not fixating on the test object and the presence of heterotropia has been established. If the observed eye does not move as the opposite eye is covered, in each instance, binocular fixation is present, and the motion which was seen during the alternate cover phase must therefore be due to heterophoria.

(3)Recording. If the "alternate cover" phase of the cover test reveals no movement of the eyes, the entry "CT orthophoria" will be made in item 62, SF 88. If motion is seen an appropriate entry based on findings of the "cover-uncover" test will be made, such as "CT-exotropia" or "CT-esophoria." The amount and character of the deviation will be entered in item 73, SF 88.

3-12. Red Lens Test. A standard lens, Diplopia Test, Red, Stock No. 6515-346-2800, is placed before one eye. Use of the red lens in the standard trial case is unsatisfactory because of its small size and dark color. A tangent screen is placed 30 inches from the examinee, or as an alternate, a central fixation point may be used. Such fixation point should be 48 inches from the floor on a plain wall with intersecting lines at 45-90-135-180 degrees running at least 20 inches from the point of fixation. The lines may be marked at 4-inch intervals and a cord 30 inches long fastened at the fixation point to determine testing distance. The patient's eyes should be on an exact line perpendicular to the fixation point so that the head and eyes are not tilted in any direction. The patient should be seated on an adjustable stool and his head steadied by placing his chin on a chin rest so that the visual axis will not be altered during testing. A point of light then is moved outward in the six cardinal directions from the center of the screen, right left, up and to the right, up and to the left, down and to the right, and

TABLE 3-6.

1955 CALIBRATION SCALE FOR SCHIOTZ TONOMETERS

Approved by the Committee on Standardization of Tonometers of the American Academy of Ophtalmology and Otolaryngology.

R	*5.5 gm.*	*Load, gm. 7.5 gm.*	*10 gm.*	*15 gm.*
Tonometer Reading		*Pressure, mm. Hg*		
0.0	41.5	59.1	81.7	127.5
0.5	37.8	54.2	75.1	117.9
1.0	34.5	49.8	69.3	109.3
1.5	31.6	45.8	64.0	101.4
2.0	29.0	42.1	59.1	94.3
2.5	26.6	38.8	54.7	88.0
3.0	24.4	35.8	50.6	81.8
3.5	22.4	33.0	46.9	76.2
4.0	20.6	30.4	43.4	71.0
4.5	18.9	28.0	40.2	66.2
5.0	17.3	25.8	37.2	61.8
5.5	15.9	23.8	34.4	57.6
6.0	14.6	21.9	31.8	53.6
6.5	13.4	20.1	29.4	49.9
7.0	12.2	18.5	27.2	46.5
7.5	11.2	17.0	25.1	43.2
8.0	10.2	15.6	23.1	40.2
8.5	9.4	14.3	21.3	38.1
9.0	8.5	13.1	19.6	34.6
9.5	7.8	12.0	18.0	32.0
10.0	7.1	10.9	16.5	29.6
10.5	6.5	10.0	15.1	27.4
11.0	5.9	9.0	13.8	25.3
11.5	5.3	8.3	12.6	23.3
12.0	4.9	7.5	11.5	21.4
12.5	4.4	6.8	10.5	19.7
13.0	4.0	6.2	9.5	18.1
13.5		5.6	8.6	16.5
14.0		5.0	7.8	15.1
14.5		4.5	7.1	13.7
15.0		4.0	6.4	12.6
15.5			5.8	11.4
16.0			5.2	10.4
16.5			4.7	9.4
17.0			4.2	8.5
17.5				7.7
18.0				6.9
18.5				6.2
19.0				5.6
19.5				4.9
20.0				4.5

down and to the left. The examinee is instructed to follow the light with his eyes without moving his head and to report either a change in the color of the light (suppression), or a doubling of the light (diplopia). Change in the color of the light should be demonstrated at the beginning of the test by use of the occluder, showing that it may be either red, white, or pink. Verification of the understanding by the examinee is made by moving the light into one of the upper diagonal fields until the brow cuts off the view from one eye. A change in color should then be reported by the examinee. To avoid the danger of routine negative response to testing, a 5 diopter prism placed base up or base down before one eye will produce diplopia which should be reported by the examinee. This prism may be alternated with a plano lens of the same size in order to confuse the examinee. If diplopia or suppression develops when no prism is being used, the point on the screen at which this occurs is noted and recorded.

3-13. Near Point of Accommodation. A Prince rule and an accommodation card will be used. The zero point on the rule will be placed 15mm. from the cornea. The card will be placed near enough to the eye that the examinee cannot read it and will be slowly moved away until the subject can correctly read print having a vertical height of 1mm. (.62M or J2). The distance from the eye will be read from the Prince rule in diopters of accommodation and recorded. If a Prince rule is not available, diopter values can be computed by dividing the near point in inches into 40 or in centimeters into 100. If examinee wears correcting glasses, these will be worn while near point of accomodation is being determined.

3-14. Intraocular Tension:

a. Examining Procedure. Intraocular tension will be determined on all examinees who are 39 years of age and older. The examination will be performed by a physician optometrist or technician who has received instruction in the proper performance and interpretation of this test. The instrument to be used is a calibrated Schiotz tonometer (Stock No. 6515-382-6100). This instrument measures the depth of indentation of the cornea of the eye produced by a given force acting over a constant area. The indentability of the eye is determined in part by its internal pressure, but is not identical with this pressure, nor does it vary absolutely with it. It offers, however, a very satisfactory way of judging the approximate intraocular pressure. The scale reading of the tonometer, while it rests on the eye of the examinee, is translated to calculated intraocular pressure by the use of a calibration table (See table 3-6), and the pressure will be entered in item 69, SF 88.

b. Technique. Tonometry should be as simple and brief as possible. A long buildup to the patient may excite him and affect the readings, as may abruptly confronting him with an instrument poised just above the eye. Lay the examinee back comfortably in such a manner that the plane of the face is parallel to the floor. Take care that the neck is not hyperextended and that there is nothing constricting the neck which would increase jugular pressure. A short acting topical anesthetic will be used and the examinee will remain under observation for 30 minutes to ensure the absence of adverse reactions as well as foreign bodies impacted during examination.

(1) Do not use tonometer on examinees suspected of having conjunctivitis.

(2) Be sure that the tonometer zeroes properly on the test block which is provided with each instrument. At the same time make certain that the plunger and the needle move with perfect freedom.

(3) Do not use toxic solutions for sterilization. If an ultra violet sterilizer is not available, use aqueous benzalkonium chloride in solution no stronger than 1:5000, being careful to wipe the solution from the base plate prior to placing the instrument on the cornea.

(4) Use the basic 5.5 Gm weight for the screening examination. If the scale deflection is less than four units, use a 7.5 Gm weight or more as needed to bring the deflection to 4 or greater on the scale.

(5) Perform the examination promptly after instillation of the topical anesthetic.

(6) The examiner's fingers should be on the bony orbital rims while holding the eyelids open. This will prevent digital pressure on the eyeball which would result in falsely high pressure readings.

(7) Before placing the instrument on the eye to be examined. be sure that the patient is relaxed and that his other eye is open, and has an unobstructed view of an object which will allow constant fixation at the proper angle during the pressure determination.

(8) Watch for slight smooth and regular fluctuation of the needle. This indicates that the instrument is correctly placed and is functioning well since this reflects the actual pressure pulsation within the eye.

(9) When the pressure obtained is abnormal, record the plunger weight and scale reading in item 73, SF 88, in addition to the pressure reading in item 69.

3-15. Visual Tests for the Detection of Malingers. A careful external examination, ophthalmoscopic examination, and determination of refractive error will visual defect and exaggerate its effect.

(2) Alertness and Ingenuity of Examining Physician. No hard-and-fast tests can be prescribed for the detection of these cases. Much depends on the alertness and ingenuity of the examining physician.

(3) Tests with Prisms Not Applicable. The tests with prisms are not applicable here, for pretended blindness in one eye is not claimed but simply an alleged diminution of visual acuity.

(4) Test at Different Distances from Chart. The person suspected of malingering should be placed at 20 feet from the test chart and directed to read the letters. The results should be noted. The examinee should then be brought up to 10 feet from the card and retested. If he still reads only the same line and does not read any of the smaller type, he is malingering.

(5) Trial Frame Test. Examiner will place a trial frame upon the examinee's face and put before the sound eye a high convex lens (+ 16D) and before the weak eye a plane or weak lens (0.25) which will not interfere with vision. If letters placed at a distance of 20 feet are read, the fraud is at once exposed.

(6) Oblique Examination. This is conducted with condensing lens and loupe to determine corneal or lenticular opacities.

(7) Ophthalmoscopic Examination:

(a) The malinger will probably resist the ophthalmoscopic examination by frequent winking or rolling of the eyes. In this event, the examinee should be cautioned that a report of his vision must be made, and further examination should be postponed until after the next few persons have been examined.

(b) The ophthalmoscope will be used as an aid in estimating the refractive error. If no error of marked degree exists and the media and fundi are normal, the relation between the alleged vision and the refractive condition furnishes an important clue. If the error is about +4 or —2, the visual acuity could be about 20/100, but when the defect cannot be accounted for objectively and the vision is brought from 20/100 to 20/50 or 20/30 by means of a low plus or minus glass, the examinee is malingering.

(8) Retinoscopy. Examiner will look for corneal and lenticular opacities and estimate refractive errors.

(g) The person's occupation in civil life may have been such that it could have been followed without more vision than he claims.

h. Cases of malingering are occasionally found in which the persons complain that they see double. These must be investigated with the application of the ordinary tests as if they were genuine and every precaution taken to guard against a serious nerve lesion being overlooked.

be needed in all cases.

a. Malingers may feign inability to open their eyes, total loss of vision in one or both eyes, or impaired vision in one or both eyes. Occasionally, an inflammation in the eyes will be produced by putting sand or other irritating substance under the lids.

b. Malingers who wish to evade military service by feigning impairment of vision may be divided into two classes, as follows:

(1) Those who claim total loss of vision in one eye.

(2) Those who claim partial loss of vision in one or both eyes. Either group may have a normal acuity of vision or may exaggerate a defect actually present.

c. The following equipment will be available:

(1) Trial frame, blank, spherical lenses: +16, +3, +0.25, —3, —2, —1, —0.25.

(2) Two prisms, one 6° and one 10°.

(3) Ophthalmoscope (electric battery in handle).

(4) Condensing lens.

(5) Loupe.

(6) Special illiterate test cards.

(7) One stereoscope with special card.

(8) Retinoscope (electric, with battery in handle).

(9) Ruler about 1 1/4 inches wide.

(10) Three disks of polaroid 36 mm. in diameter and 2 mm. thick.

d. The principle involved in the polaroid test is that light polarized in any given meridian by polaroid screen is selectively absorbed by an analyzing polaroid screen, the axis of which is at an angle to the axis of the polarizing screen. The test will be conducted as follows: Three disks of polaroid 36 mm. in diameter and 2 mm. thick are required. They are held in the ordinary trail frame with the handle corresponding to the polarizing axis. One polarized disk is placed before each eye with the polarizing axis horizontal. The additional disk is placed in front of the good eye with its axis also horizontal. The individual is then asked to read the smallest possible line of letters on the test chart with both eyes open. Immediately, the third polaroid disk is rotated so that the polarizing axis becomes vertical or the length of time that it takes to read three or four letters. The rotation of third disk to the vertical position prevents the passage of any light so that if the reading of the test chart is continued during this time, the poor eye obviously is functioning. The disk may be used with correcting spectacle lenses if necessary. Both eyes must be open at all times. Also, the good eye must be occluded by the opposed polaroid disk for only a short period at a time so that the examinee does not become aware of the momentary elimination of visual acuity in that eye.

e. To verify total loss of vision in one eye, the following tests may be used:

(1) Binocular Vision. (A 6° prism, base down, is placed before the admittedly sound eye while the individual looks at a distant light. If he sees two lights, binocular vision is proved. The examiner may vary the test by placing the prism before the "blind" eye, either base up or base down.

(2) Double Vision. A prism of 6°, with base outward, is placed before the "blind" eye. If there is any sight in this eye, double vision will be produced and the eye will be seen to move inward to correct it and fuse the two images.

(3) Monocular Diplopia. The alleged "blind" eye is covered. A prism of 10°, with the apex up, is placed before the "seeing" eye in such a position that its edge lies horizontally across the center of the pupil. This produces monocular diplopia. The prism is then moved upward so as to be completely in front of the good eye and at the same time the "blind" eye is uncovered. If diplopia is produced or admitted, there is sight in the "blind" eye.

(4) Test with Trial Glasses. A high plus glass is placed before the good eye and a low plus or minus before the "blind" eye. If the distant type if read, the vision in he "blind" eye is good.

(5) Stereoscope Test. This may be made with ordinary stereoscope, the printed matter so arranged that certain portions of it are alternately absent before one of the eyes.

(6) Bar Test. A ruler about 1 1/4 inches wide is interposed vertically midway between the two eyes at about 4 to 5 inches' distance; the examinee is directed to read from a printed page with lines at least 4 inches long. If able to read all of each line, binocular vision exists.

(7) Pupil Action. The action of the pupil will be carefully tested; there usually is no movement to light stimulation when the eye is blind.

f. To verify partial loss of vision in one or both eyes, the following tests may be used:

(1) Most Common Manifestation of Malingering. The most common manifestation takes the form of a statement that one eye is imperfect. Individuals pleading this disability may be divided into two classes:

(1) Those who pretend to have a visual defect.

(b) Those who are aware that they have a

Procedure for Administering the Tests

The Telebinocular should be adjusted so as to give each eye a full view of its field. Care should be taken that no outside glare interferes with the tests.

It is best to place all stereotargets in the holder. This saves time and permits the control of exposures in the tests where the time element is a condition of the test, as in Tests III and IV.

Seat the subject at the instrument and near enough to it so that his back and head are erect, shoulders level but relaxed, and feet flat on the floor or comfortably placed on the rung of the stool or chair.

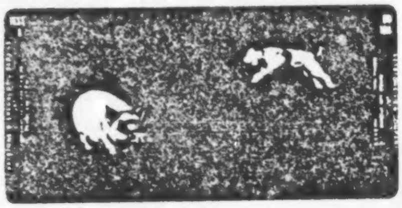
The instrument is then adjusted to the required height to maintain the desired body posture. Comfortable and correct posture is essential—first, because general body posture is also concerned with seeing; second, because uncomfortable posture will distract the subject's attention from the test. After correct posture has been **attained**, it is to be **maintained** during the entire testing period.

If bifocals are worn, it will be necessary to adjust the instrument and glasses so that the subject's line of vision may pass unobstructed through the bottom of his bifocal segment for the near-point tests, or the amount of the add may be inserted in the lens wells.

Questions

Instructions and Interpretations

TEST I — SIMULTANEOUS PERCEPTION — AT ∞, FAR POINT



DB 10A

"What do you see?"

or

"Do you see dog?" "And a pig?" (Pointing to each.) "Is the dog directly over the pig?"

If a small child seems afraid of the Telebinocular at first, introduce the test by asking "Do you know about the little pig that went to market?"

The sole purpose of Test I is to determine whether both eyes see the same time.

If simultaneous perception is not present, only Tests V and VI can be given.

If the dog and the pig are seen alternately, alternate suppression is indicated.

If only the dog, or the pig, can be seen, except by occluding the dominant eye, gross suspension is present.

If the dog, or the pig, cannot be seen when the other eye is occluded, blindness or high amblyopia exists.

Small children may be asked to point to the pig on the **right** side or to the dog on the **left** side, to verify that they are seeing both at the same time.

KEYSTONE TELEBINOCULAR INSERT

This insert will assist you in understanding how the procedures you learned in this block fit in with the sequence of tests as they are normally performed on the Keystone Telebinocular (FSN 6515-082-1657). Some of the tests performed on the Keystone instrument are similar to those described in the AFM 160-17 insert on the VTA-ND.

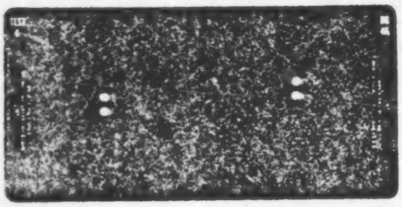
if the movement continues in one direction, recording should not be made until a movement in that direction has stopped. Recording may be made thus: 1——>—1.

Findings falling to the **left** of the "EXPECTED" column indicate exophoria; to the **right**, esophoria.

The posture of the visual axes at the instant of exposure is indicative of their "readiness" to collaborate in the binocular act, and of the speed and efficiency of seeing.

Marked deviations from parallelism or postural instability denote unbalanced accommodative-convergence relationships.

TEST IV — BINOCULAR COORDINATION — AT ∞, FAR POINT



DB 4K

"How many balls do you see?"
or
"Do you see two, three, or four balls?"

1. The target should be exposed **quickly.**

2. The patient should report how many balls are seen **immediately** upon exposure. There may be:

   a. **Three,** remaining three and in **vertical** alignment. Shows that the eyes are postured habitually for single binocular vision, indicating fusion "readiness."

   b. **Three,** remaining three, but **in oblique** alignment. Usually associated with a high phoria. Indicates fusion is maintained with effort.

   c. **Four,** becoming three **instantly.** Has practically the same significance as **a.**

   d. **Four,** becoming three **slowly.**
   Indicates that the eyes are not automatically positioned for fusion, with consequent lowering of performance. Check in Doubtful column.

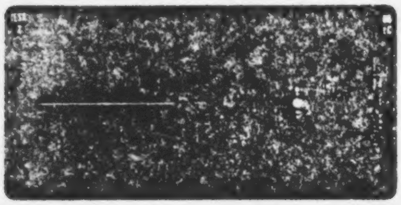
   e. **Four,** remaining four.
   Shows marked interference in accommodative-convergence relationship.

   Look for macular, perimacular, and peripheral cancellation—suppression. See "Supplementary Tests."

   f. **Two** balls.
   Shows gross suppression. Look for amblyopia and squint.

This Test may be considered a recovery at Orthophoria Test. If the Lateral Phoria is not close to Orthophoria, the patient who sees four balls is indicating that positive or negative fusional convergence is weak.

TEST II — HYPERPHORIA — AT ∞, FAR POINT



DB 8C

"Do you see a yellow line and the red figures?" (Pointing.) "What figure does the yellow line touch?"

The head should be level in the Telebinocular at all times.

If hyperphoria is reported with Rx, repeat test without Rx; the frame may be bent. (This test may well be used when adjusting glasses, especially in the case of strong corrections.)

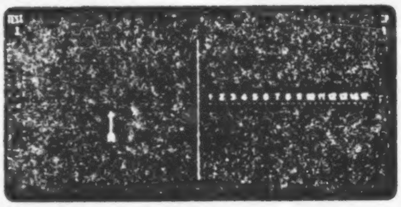
When the yellow line passes anywhere within the ball and the zero, mark "EXPECTED." When the line passes through the cross, the reading is two diopters of **right** hyperphoria. When the line passes through the star, the reading is three diopters of **left** hyperphoria.

If the yellow line fails to become stabilized and continues to move up and down, mark the limits of the swing. A variable hyperphoria has diagnostic significance.

Answers may be verified by having the patient report when your pointer, held before the **right** eye, touches the yellow line.

The fading of the yellow line at the point where it crosses a red figure has no diagnostic significance. The phenomenon is probably due to retinal rivalry.

TEST III — LATERAL PHORIA — AT ∞, FAR POINT



DB 9

"To what number does the arrow point?"

The patient is to report:

1. To what number the arrow points at the instant the target is exposed by the quick removal of the stereogram in front of it.
2. Whether the arrow remains under the initial number.
3. Whether the arrow moves quickly under some other number and remains there.
4. Whether the arrow swings, pendulum-like, between certain numbers for a time, but eventually becomes stationary.
5. Whether the arrow continues to swing.

If the arrow stands definitely at any point, recording should be made accordingly.

In many cases a response will be delayed by the apparent movement of the arrow. To assist in speeding a response, ask for a number within the range of movement. When this has been obtained, it can be ascertained how far each way the movement continues.

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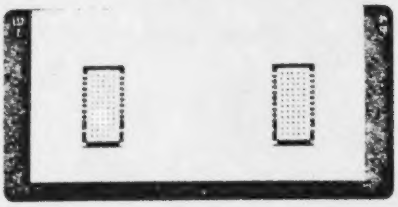
NOTE: Snellen equivalents on Tests V and VI are valid only when **one eye is occluded**:

50%	70%	84%	88%	92%	96%	98%	100%	103%	105%
20/100	20/60	20/40	20/32	20/28	20/25	20/22	20/20	20/17	20/15

DB 2D

TEST VII — STEREOPSIS — AT ∞, FAR POINT



DB 6D

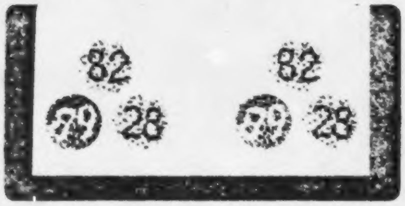
"You see (pointing to each figure in the top line) a star, — square, — cross, — heart and ball. Does one of them seem to be closer to you than the rest?
Which one in the second line?" etc.

When a visual problem arises, binocular foveal fixation is the first skill to be suppressed. (See Test V.) Since refined space judgment is based on binocular foveal fixation stereoscopic awareness also suffers loss at any early date. Deterioration of depth discrimination becomes corroborative evidence of central depression.

DB 6D is a screen-out test. Failure on any part of this test signifies need of corrective attention. When a more critical test is desired, as a criterion for progress examinations or where exact information is needed, use Stereometric Units DC1-23, or DC31-53 or the Keystone Multi-stereo Tests.

Be sure that the patient understands what he is to look for. Instructions should be given slowly and clearly. Sometimes it is necessary to point out the correct character in the top line before he understands what is wanted.

TEST VIII — COLOR-PERCEPTION TEST (FOR SEVERE DEFECTS) — AT ∞, FAR POINT



DB 13A

Read the number (pointing) in the top ball.

Read the number (pointing) in the lower left ball.

Read the number (pointing) in the lower right ball.

Do not permit the patient to study the target or delay too long.

Score by checking correct readings on the record form. Two balls, both digits, correctly read are passing. Two balls, both digits, incorrectly read indicate failure and mild red-green color blindness.

10W/D- 76-569

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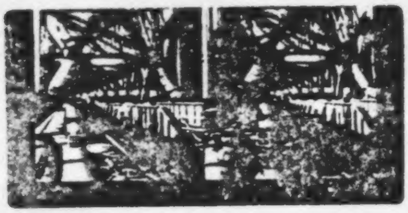
TEST 4½, 5 AND 6. — USABLE VISION, BINOCULAR, RIGHT EYE AND LEFT EYE



DB — 3D Right Eye

DB — 2D Left Eye

DB — 1D Binocular

"You see some signboards. In No. 1 (pointing) you see five white squares. And in one of these squares is a black dot. Is it in the right, left, top, bottom, or center square?"

"Where is it in the other signs?" (Use pointer.)

It will be noticed that the referential background is identical for both eyes, but that the test target, a black dot, appears only before the eye under test. This arrangement makes it possible to measure the visual response of one eye while binocular vision is maintained, as under normal working conditions. The percentage of vision demonstrated under the conditions of the test will be referred to as "Usable Vision." When usable vision falls materially below 100%, a monocular test of that eye should be made. (A blank card may be held in front of the Telebinocular tube.) Record usable and monocular scores by distinguishing symbols, such as √ for usable and a circle for monocular. (See Cumulative Record Form No. 2.)

Responses should be prompt. If the subject hesitates, indicating an effort to guess, the last previous response should be checked as final.

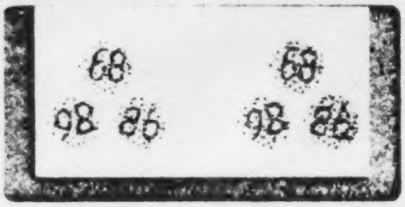
The elimination of letter targets avoids the factor of recognition of familiar contours, present in the use of the Snellen Chart. The usable vision score cannot be correlated with the findings of the standard Snellen test. While the Snellen type of test measures the maximum of monocular acuity under occlusion, the usable vision test scores the **habitual** performance of each eye under fusion. The usable vision test does not necessarily elicit maximum acuity; rather, the purpose of the test is to determine whether there has been any functional loss of vision. When the response under association is lower than the monocular finding (under occlusion), the impairment may be attributed to central suppression and signifies that a visual problem exists. It is generally accepted that the earliest skills loss occurs in the central field. Here, then, the first sign of interference between patterns is to be looked for. Consequently, Tests V and VI assume major diagnostic significance in the investigation of visual problems.

The findings secured in the usable vision test may properly be subjected to further specific evaluation. Suppose a not uncommon occurrence: a patient, doing a great deal of reading, cannot go beyond No. 6 target, but when the other eye is occluded No. 9 target is readily located. The difference in monocular and binocular performance levels can be accounted for only on the hypothesis that when the demand is for better than 20/60 vision binocularity cannot be maintained in the central field. Since much reading matter requires visual acuity above 20/60, the response signifies inadequate adaptation to the given task. This is to say, the acuity level at which suppression occurs may give information as to the nature and the extent of the existing problem.

The procedure is excellent for demonstrating to the patient the nature of his difficulty. Personal appreciation of his problem is necessary to obtain his full cooperation for whatever correction program is necessary.

The conventional examination includes no equivalent test for detecting the subtle concessions made to maintain clear, single and efficient vision.

TEST IX — COLOR PERCEPTION (FOR MILD DEFECTS) — AT ∞, FAR POINT



DB 14A

Read the number (pointing) in the top ball.

Read the number (pointing) in the lower left ball.

Read the number (pointing) in the lower right ball.

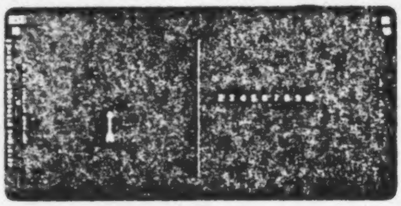
Do not permit the patient to study the target or delay too long.

Score by checking correct readings on the record form. Two balls, both digits, correctly read are passing. Two balls, both digits, incorrectly read indicate failure and mild red-green color blindness.

NEAR-POINT TESTS

It is generally accepted that fatigue is caused by prolonged concentration within a restricted area. The responses evoked in the following near-point tests becomes, therefore, especially informative when the chief use of the eyes is at close range.

TEST X — LATERAL PHORIA — AT 2.50, NEAR POINT

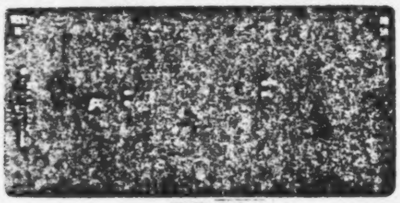


DB 9B

Procedure and interpretation same as for Test III.

Indicates the effect of 2.50 diopters of accommodation on the position of the visual axes.

TEST XI — BINOCULAR COORDINATION — AT 2.50, NEAR POINT



DB 5K

Procedure and interpretation same as for Test IV.

TEST XII — BINOCULAR ACUITY — AT 2.50, NEAR POINT

DB 15

"On these balls (pointing to each in center) you see **lines, dots,** or **gray.** Which of these patterns do you see, starting with No. 1 (pointing)?"

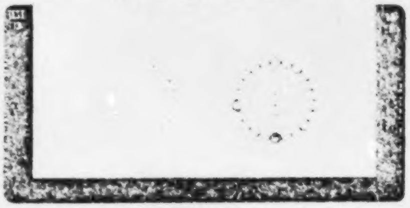
It is well to tell the patient the patterns on balls 1, 2 and 3 in this manner "Ball 1 has black dots; Ball 2 has black dots; Ball 3 has black lines."

The conditions of the test are the same as in Test V, that is to say, the Usable Vision of each eye can be determined while fusion is maintained. The interpretations pertinent to Test V are valid here. The general observations at the head of the Near Point section should be noted, because suppression of central fixation at the working distance may be more directly significant of the existing visual problem.

Do not hurry the subject, but at the same time do not give him too much time for study or allow him to guess. When a ball is miscalled and obviously not seen clearly, or when guessing is obvious, check on the record form at this point.

NOTE: In dealing with children it is well to allow them to proceed beyond the point where they miss one ball. Do not stop the child on his first miscalled ball. If he can go on and give additional correct responses, let him proceed until he makes two mistakes successively. Then say, "Tell me again what you saw on Ball 6 (Miscalled)." Often it will be found that the child simply made a mistake in reporting on the first miscalled ball.

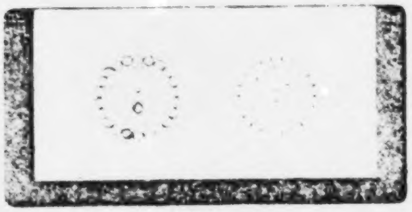
TEST XIII — USABLE VISION, RIGHT EYE — AT 2.50, NEAR POINT



DB 16

Procedure is same as in Test XII.

TEST XIV — USABLE VISION, LEFT EYE — AT 2.50, NEAR POINT



DB 17

Procedure is same as for right eye.

SNELLEN EQUIVALENTS:

NOTE: Snellen equivalents on Tests 12, 13, and 14 are valid only when **one eye is occluded:**

10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
20/200	20/100	20/67	20/50	20/40	20/33	20/28	20/25	20/22	20/20
102%	103%	105%							
20/18	20/17	20/15							

ATC—SHEPPARD AFB TEX [illegible]